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Arduino Based Automatic Irrigation through Wireless Sensor Networks Using IoT

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Abstract--The main purpose of Arduino based automatic irrigation system is to conserve water and reduce the man power. This system has soil moisture sensors, pH sensors, humidity sensors, ZigBee devices, Motor, Relay, Weather forecast application, Bluetooth Module and WIFI Module which are interfaced with Arduino boards. The sensors and ZigBee module makes up a wireless network of sensors. This wireless network of sensors will sense the moisture content from the soil, moisture content from the air and pH of the soil and then send the data to the main unit which will further send this data to user's mobile application using Bluetooth module and also to the web server using IoT through Wi-Fi Module. The system has low cost and can reduce the wastage of fresh water due to over watering the agricultural land and can also remove or reduce the need of farmer.

Index Terms— Moisture sensor (YI-69), Humidity sensor, pH sensor, Arduino, ZigBee, Bluetooth Module (HC-06), Wi-Fi Module (ESP8266), Wireless Sensor Networks (WSN), Android application, Internet of things (IoT), ThingSpeak.

I. INTRODUCTION

Pakistan is an agricultural country and agriculture is the backbone of Pakistan's economy. Irrigation system is the only source of agriculture in some places of Pakistan. This paper presents the idea of Arduino based Automatic Irrigation system through Wireless Sensor Networking (WSN) using IoT. This system has a wireless network of Soil moisture sensors, Humidity sensors and pH sensors. The soil moisture sensor will measure the value of moisture content present in the soil, if the moisture level is below the certain threshold and soil is dry then the motor will turn on automatically and land will get water and when the soil is wet the motor will remain turned off. This will reduce the man power and wastage of fresh water. Along with Soil moisture sensors pH and Humidity sensors are also used to make the system more advanced.

PH sensors are very important in analyzing the agricultural land. We know that pH below 7 is acidic, pH above 7 is alkaline and pH at 7 is neutral. Most soils do well for pH of 5.5 for organic soils and pH of 6.5 for mineral soils. By measuring the pH of the soil suggestions can be given to farmer whether to add chemicals or not in order to get the desired pH needed for the good crops growth. Humidity sensors are used for measuring the moisture content present in the air. Some crops grows best in humid climate so humidity is also an important factor in agricultural land.

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Furthermore, a weather forecast application has been interfaced within the system. The weather forecast application will notify the system about the rainfall. If there are chances of rainfall on a particular day and also there is requirement of water in the field at that particular day then the system will not provide water to the field on that particular day due to the high chances of rainfall. The system has been made in such a way that weather forecast application has been set to the higher priority. So the system will first check the weather forecast application then after checking the weather forecast application it will check the status of the soil whether there is need of watering or not. Since fresh water is a precious resource therefore we used weather application within the system in order to save the land from the overwatering in the rainy days and also conserve the fresh water.

With the advent of Arduino boards and cheap sensors it is now easy to make systems that can monitor the soil and automatically irrigate the land [1].A relay is used which can turn motor ON/OF automatically according to water requirements [2]. When the motor will start a pump is connected with the water tank which will give water to the land. The soil moisture sensor will be placed in the root zone of the plants and the humidity and temperature sensor will be placed on the ground level. The soil moisture sensors and humidity sensors are also connected with Arduino and ZigBee module making a whole system of Wireless sensor networks. This system consisted of soil moisture sensors, humidity and temperature sensors, Arduino and ZigBee makes up the transmitter side of the system. Soil moisture sensors and ZigBee module are interfaced with Arduino on the transmitter side. ZigBee module will transmit the data wirelessly from transmitter side to receiver side where another ZigBee device is placed and interfaced with Arduino also known as the control unit. The Arduino will send the data further to an open source

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android application and an open source web page using ThingSpeak platform. The android application is using a Bluetooth module (HC-06) which is interfaced with Arduino. Similarly web page is using a WIFI module which is interfaced with Arduino. The monitoring of the irrigation field can be done using the android application or using the ThingSpeak web server. This system is not only cost effective but also eliminates the use of man power and wastage of fresh water due to overwatering. The system helps to improve the crop performance by irrigating it at the right time and saves from irrigating the land at the wrong time of the day [3]. This irrigation system allows irrigation in places where there is water scarcity thereby improving sustainability.

II. EXISTING SYSTEM

Most of the existing systems which are available in market have GSM architecture. These existing system consists of general packet radio service (GPRS) module as a receiver unit. The data from the wireless sensor networks are send to the GPRS module. The GPRS unit has a duplex communication based on a cellular internet interface which is used in 2G and 3G cellular global system for mobile communications (GSM).Though GSM have more range and more practical for larger areas but it costs for sending data every time, whereas ZigBee is cost free solution. Moreover, you have to take permission for using GSM band whereas ZigBee has free license band which everyone can use and does not need any permission. However, you cannot use ZigBee for large areas as it does not have enough range to transmit or receive data at larger areas.

III. IMPLEMENTED SYSTEM

The proposed system is the combination of both hardware and software. The hardware section consists of embedded system [1] compromising of transmitter section and receiver section. The transmitter section in Fig.1 consists of soil moisture sensor (YL-69), pH sensor, Humidity and Temperature sensor (DHT-11), Relay, Water pump, ZigBee S1 and Arduino Board. The soil moisture sensor has two parts the electronic board and the probes [4]. When the probes are dipped into the soil and current is passed if there is greater moisture content present in the soil then the resistance will be low and more current will pass through it. And if the moisture content is low then the resistance will be high and low current will pass through it. The data will be read by analog pins of Arduino board at the transmitter side. The smaller output values implies greater moisture content in the soil. DHT11 (Digital Humidity and Temperature) sensor is also used to measure the temperature and humidity of the surroundings. The sensor consists of a NTC temperature measuring component along with a resistive type humidity measuring component [5]. The pH sensor measures the voltage (potential difference) of the solution. The soil moisture sensor, pH sensor and humidity sensors are interfaced with Arduino board. These sensors will sense the values from the soil and send the output to the LCD screen. Then in order to transmit values wirelessly to the receiver side ZigBee is used which is also interfaced with Arduino board on the transmitter side. ZigBee is used for the wireless communication between the transmitter and receiver side. ZigBee uses license free band so anyone can use it. ZigBee will read these values on the transmitter side and transfer these values wirelessly to the ZigBee which is placed on the receiver side. The ZigBee S1 module can be used both as a transmitter or a receiver. The ZigBee on the transmitter side is taking data from the receiver side and transmitting it to receiver side where another ZigBee device has been placed which takes this data and send further to control unit. The control unit is further connected with Bluetooth module and Wi-Fi Module. The control unit processes the data and sends the data to the android app using the Bluetooth module and also to the internet using WI-FI module. In order to get data from Control unit through Wi-Fi module we used ThingSpeak which is an open source internet of things (IoT) application. So in this way the values can be displayed on the web server in the form of graph.

Following are the software which are used Arduino, Cool term and putty. Arduino for interfacing all the devices on transmitter and receiver section. Most of the coding part is done in Arduino software for interfacing sensors and ZigBee with Arduino and then send data to the main unit. All the sensors and ZigBee are programmed on Arduino on the slave node. Similarly the ZigBee module, WI-FI module, Bluetooth Module and weather forecast application are programmed on the Arduino software. For configuration of the ZigBee Module and the WI-FI Cool term and putty software were used. Cool term software is used for the configuration of ZigBee module. AT commands are used for the configuration of ZigBee devices. Both ZigBee modules are configured first with the help of cool term software then after configuration ZigBee devices are connected to Arduino. Similarly for the configuration of WI-FI module putty software is used. AT commands are used for setting the baud rate and for setting the WIFI modes. There are three modes in which WIFI module can work station mode, access point mode and both station mode and access point mode. The WIFI module is configured first then after configuration it is interfaced with Arduino. In order to get data transferred on the web page an open source internet of things application is used

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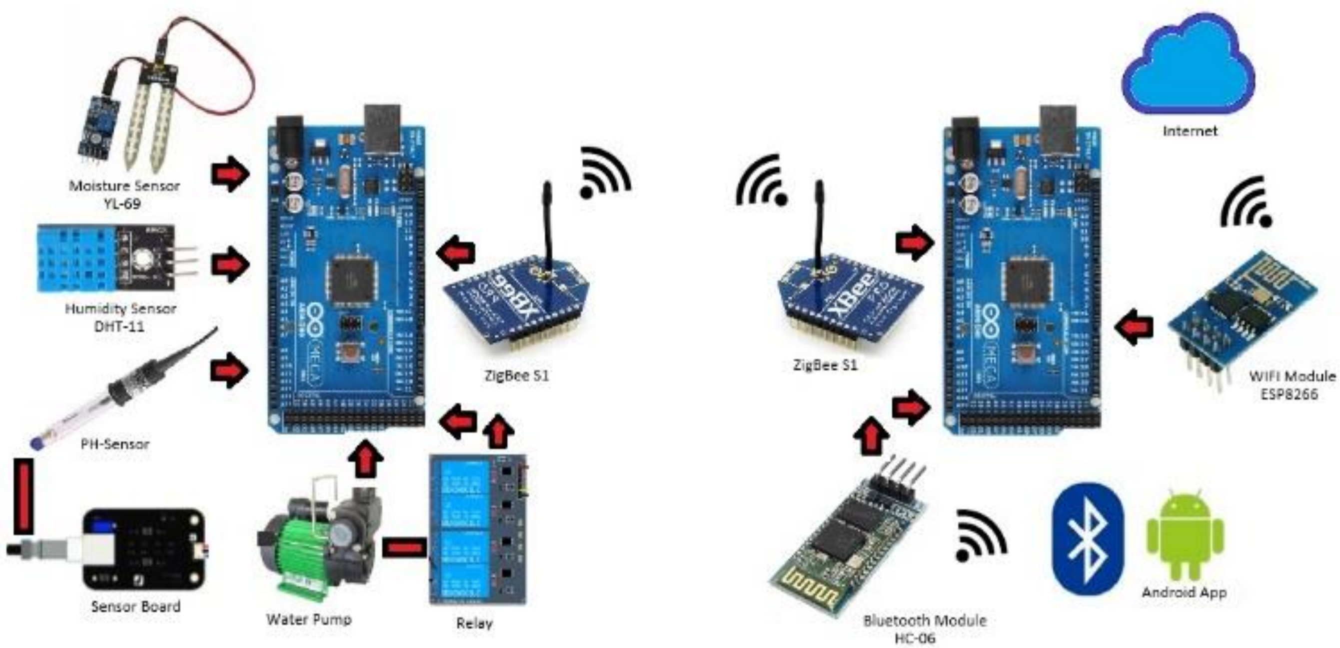

Transmitter Side Receiver Side

Fig. 1 Master-Slave connection diagram

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which stores the data from the things through the WIFI module using the HTTP protocol over the internet. In order to connect ThingSpeak server with the Arduino a WIFI module is used.

You can access ThingSpeak server by getting the SSID, password and key from the server and put the information in Arduino software. Also an open source android application (HC-06) is used to monitor the data through the Bluetooth module. The HC-06 is connected to the Arduino at the main unit. The data from the Bluetooth module can be accessed by any of the device which supports android applications on its operating system. The Bluetooth Module uses 2.4GHz and has a range between 5-10m.

The implemented system shown in the Fig.1 shows the Master-Slave connection diagram. The wireless communication between the slave node and the master node is done through ZigBee module which is using 2.4 GHz and has a range of 10-100 meters. The smaller range of ZigBee modules is due to its low power consumption. The transmission over long distances can be done by using a mesh network of intermediate devices in order to reach the distance ones [6].

IV. System Test

The implemented system was tested in a home loan where Mentha crop was grown. The slave node (Transmitter) was placed in the soil and the master node was placed inside the home to monitor the results. The pH of the soil was in between 5.5-6.5. The moisture level of the soil was being checked at the regular time intervals. When the moisture level of the soil becomes lower than the threshold value the system automatically power on the motor using relay and water is

Table 1. Implemented Sensors and Measured Variables

Measure Variable	Sensor	Working Principle	Range
Moisture Level	YL-69	Resistivity of Soil	ρ = (0 -1024)Ω·m
Humidity	DHT-11	Electrical Resistance	S = (0-100)% /±(2-5)%
Temperature	DHT-11	Electrical Resistance	S = (-40-125)°C / ±0.5°C
PH	C1101A	Potential Difference	PH range = 0-14

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flowed through the pump towards the crop. Similarly the Humidity and temperature were measured along with the pH and the soil moisture sensors at the regular time intervals. Furthermore, the weather forecast application was working accordingly to the rain chances. When the chances of rainfall becomes high the motor remained turned off. Table 1 shows the measured variable of the sensors and there ranges. Fig.2, Fig.3 and Fig.4 shows the tested results and graphs taken from the implemented system which has been shown on the android app and the ThingSpeak web server.

V. Results

The android application is used to monitor the system. Fig.2 shows the results of the data collected from the soil moisture sensor on android application. The greater values of output in Fig.2 indicates that the soil needs the water,

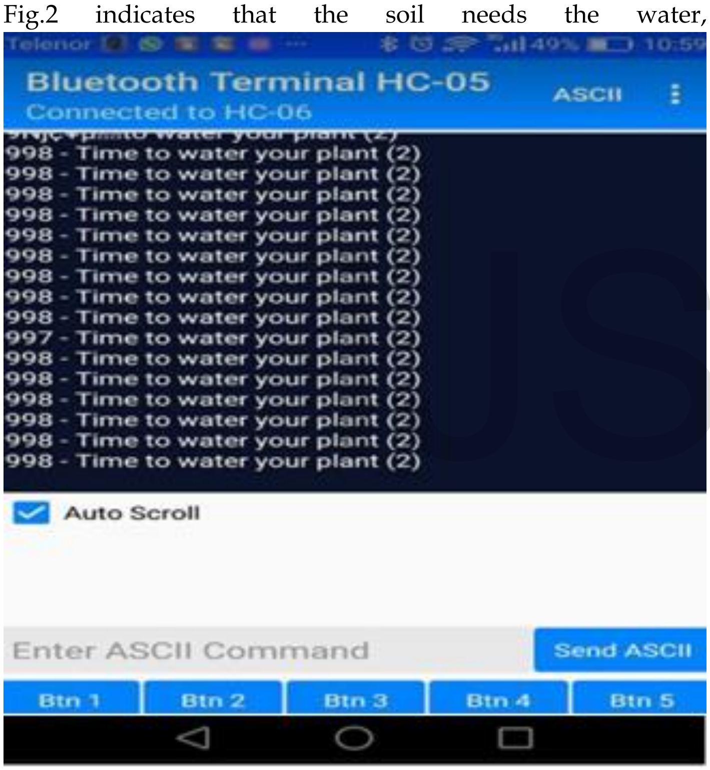

Fig.2 Results on Android Application

To monitor the results on the internet ThingSpeak web server is used. Fig.3 and fig.4 shows the graphical results taken from the implemented system. The x-axis of both the graph shows the time at which the data values have been taken and on the y-axis the threshold values is given on both graphs. If the threshold values is greater the soil needs the water and if the threshold value is less than the soil does not need water. Table 1 indicates the range on the threshold value of the soil moisture sensor (YL -69) as it can be seen from the results on the android application the moisture level is closer to the upper range on the threshold range so it implies that the soil needs the water.

Furthermore, accuracy of results can be seen from the ThingSpeak server as graphical results in Fig.3 and Fig.4 can be seen for both the outcomes when the water is needed and when there is no need of the water.

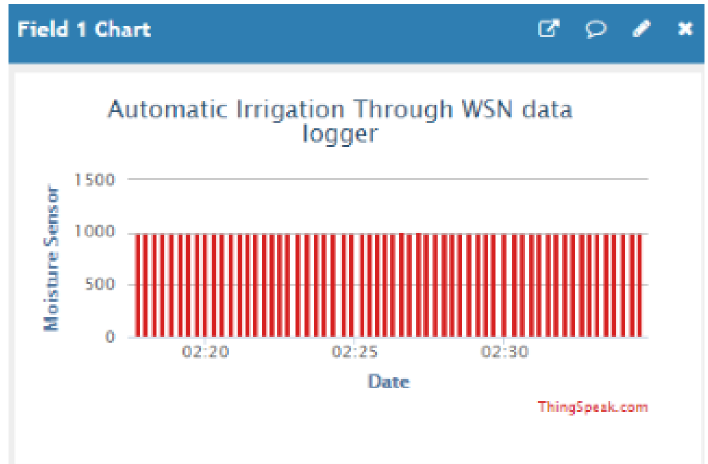

Fig.3 Results on web page using ThingSpeak

The greater values of output in the graph of Fig.3 indicates that the soil needs the water. The server sends this information back to the control unit. The relay is connected to the control unit which will turn the motor ON and then water will be provided to the field using the water pump.

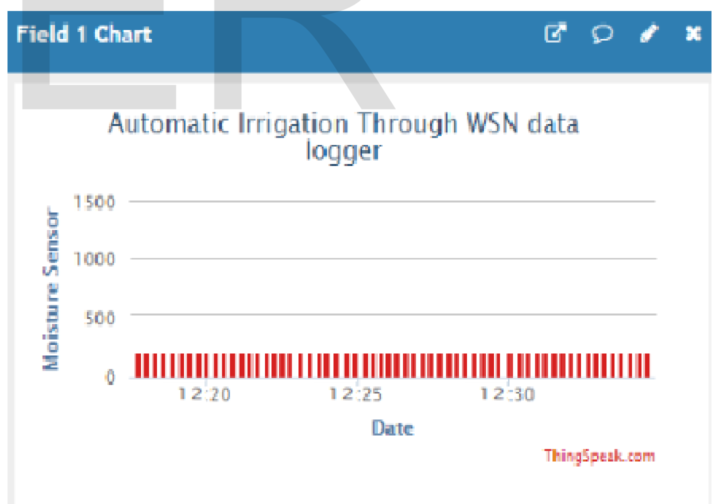

Fig.4 Results on web page using ThingSpeak

The lower values of the resistivity of the soil in the graph of Fig.4 above indicates that the soil does not need water. The motor will remain turned off in this case.

VI. Acknowledgement

I owe my deep gratitude to my supervisor Sir Mian Ali Mujtaba who took keen interest and guided me throughout the project. He was so cooperative during different phases of the project and helped me to complete this project successfully.

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VII. Conclusion

The implemented automatic irrigation system based on Arduino platform using wireless sensor networks presented a good performance when it is implemented in a home garden. As the implemented system is automatic the labor need is eliminated. Also due to open source platforms and low power consumption of ZigBee module the system is very cost effective. The use of weather application within the system can save the crops from overwatering in rainy days. This system can be employed in places where there is water scarcity. Moreover, the system can also be employed in a commercial green house. The implemented system can be monitored from long distances allowing you to take appropriate actions to avoid crop loss on time.

As the system has low range so in future we can extend this work for larger areas by using the mesh networks which can help in increasing the range.

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