Design and Implementation of Smart Irrigation System Using Wireless Sensor Network Based on Internet of Things

Neamet Akeel Fawzi, Ali Sadeq Abdulhadi Jalal

Abstract— Environment monitoring covers wide geographic areas to monitor aspects of the environment, such as detection of forest fires, and volcanoes before they happen also plant agricultural and irrigation monitoring. It consists of a set of sensor nodes distributed in the environment to monitor environmental phenomena. In this work, a smart irrigation system is designed for rice plant farms based on Wireless Sensor Network (WSN). The reason behind the choice of the rice plant is that it consumes a large quantity of water in Iraq while the country suffers from water scarcity in summer period. Telosb sensor nodes were used to collect data, process, analyze and send information about (temperature, humidity, energy, light, and water level). Nodes were programmed using Tinyos 2.1.2 under Linux operating system. A middleware program was also designed using Python language which uploads data from the Base station to the cloud server. A website was also implemented based on Google cloud infrastructure, where it displays all information to farmers in the farm.

Key Words — WSN, Smart irrigation, Internet of Things.

1 INTRODUCTION

MOST of the farmers use traditional irrigation system for watering their crops in the farm, this system is inefficient and takes a lot of time and effort. In order to overcome this problem, smart irrigation system is used [1].

A smart watering system is a system that gives water to the plants where water is needed with the required amounts at the correct location and the best time to increase productivity and enhance the goodness of plants as shown in Fig 1. When compared with the traditional watering systems that work on the principle of timer-based irrigation where it gives water to the plants randomly without any feedback. In order to improve production efficiency and goodness a smart irrigation system is used [2].

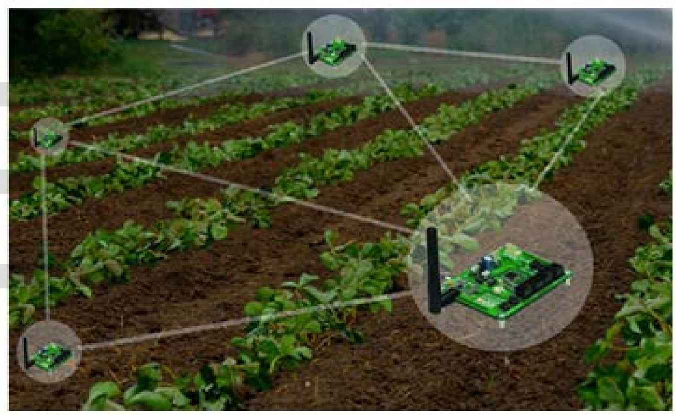

Fig.1. Smart irrigation system

The main technology used here is Wireless Sensor Networks (WSNs) which have gotten attention in recent years. This technology enhances the conventional watering system and allows irrigation system to be a highly efficient, and low water usage. WSN is used for gathering, storing and sharing sensory data [3].

Internet of Thing is defined as one of the significant topics which allow devices "things" to communicate with each other through the internet without any human interaction [4]. These devices may be a small device such as a smartphone, Laptop, and sensor nodes or large scale device, such as vehicles, cars, airplane, and ships. All these "things" must have access to the Internet.

There are some divergence between IoT applications and regular internet applications which are [5]:

1. Internet applications such as web pages are static and may be updated randomly for days or weeks.

2. Techniques of uploading and downloading data from and to the cloud server, where in a conventional internet application, the transfer of data is controlled by humans while in IoT the data will move automatically without human interaction.

Neamet Akeel Fawzi is currently pursuing masters degree program in Networks Engineering and Internet Technologies in Al-Nahrain University, College of Information Engineering, 10069 Iraq, PH-009647722646434. E-mail: eng_nono_it1@yahoo.com
Ali Sadeq Abdulhadi Jalal is currently a SMIEE and Assistant Professor in Al-Nahrain University, College of Information Engineering, 10069, Iraq, PH-009647901750151. E-mail: ali.sadeq@coie-nahrain.edu.iq

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1.2 Related Work

C Marios et al [6] used a smart gardening system. The system consists of special soil humidity sensors, electro-valves, two types of sensor nodes (TelosB and IRIS), and a Java application that is used for data collection. This system is used to maintain soil humidity levels.
Ragheid Atta et al [7] used three sensor nodes. Each sensor node measures soil moisture and can also measure temperature and humidity. They designed an automated watering system in dry regions such as Saudi Arabia, where water resources are very limited.
L Karim et al [8] explained the Energy Efficient Zone-based Routing Protocol (EEZRP) works by deploying a minimum number of sensor nodes for agricultural monitoring where base station (BS) is placed outside of all zones.
J Uddin et al [9] designed a smart phone to control the irrigation system which send and receive information from the farmer.
Luciano L. Pfitscher et al [10] proposed an automated watering of rice crops using (GPRS), water level sensors, and Supervisory Control and Data Acquisition (SCADA) to monitor and to control the water level in the farm.
Ayman M. Hassan [11] designed an irrigation system based on WSN which include a water level and water flow sensors. All sensor nodes connect to a Zigbee gateway that collects sensor data periodically and sends it to web server using GPRS connection.
S. M. Abd El-kader and B. M. Mohammad [12] improved the precision farming in Egypt. They use a APTEEN protocol in routing strategy. The network lifetime can reach 6.5 months.
A Hussein Abbas et al [13] designed a smart irrigation system which deployed in gardens or fields. It includes a smart sensing application for the detection of season and weather conditions.
P. Alagupandi et al [14] have suggested a simple and cost effective smart irrigation system. The system is displayed in an open air environment utilizing TINY OS based IRIS nodes to measure the humidity level of the crop. The proposed plan is easy to perform and requires a minimal number of IRIS sensor nodes.
J Gutiérrez et al [15] used a smart phone to capture and process digital pictures of the soil and estimate optically the water level. An Android App was designed to manage a digital camera and the Wi-Fi system.
N. Kabilan; M. Senthamil Selvi [16] used Automatic watering systems to control the amount of water flow in the farm. In this work Internet of Things (IoT) is used. The automatic watering system is designed in such a way that the cost for installation and maintenance is very much reduced than the existing water flow systems.

2 System hardware

This section explains the use of sensor nodes called Telosb for measuring temperature, humidity, light, and energy, and the VH400 sensor used to measure soil moisture.

2.1 Telosb Sensor

Telosb is an ultra-low power wireless module for use in sensor networks, and monitoring applications. This mote has the following general characteristics [17]:

- IEEE 802.15.4, (CC2420 RF) radio
- MSP430 Processor
- Built-in light, humidity, and temperature sensors
- 2xAA Batteries for power supply.

Telosb sensor node is shown in Fig.2.

Fig.2. Telosb Sensor Node

2.2 Water level Sensor

The water level sensor includes of a cable, which on one end has one prong is pushed inside the soil and on the other end has 3 wires are connected to the Telosb node as shown in Fig3. The black wire is connected to the ADC channel pin as an output, the red wire is connected to the Vcc pin and the bare wire is connected to the ground pin.
For the supply voltage it needs at minimum 3.3 V which we can connect directly to the Telosb mote without any other external supply [18].

Fig.3. VH400 Soil moisture sensor

The VH400 has been used as a water level sensor; some experimental test has been applied to calibrate the sensor. Table1 shows water level with its corresponding voltage produced by the sensor, where the supply voltage of the sensor is 3volt. Fig4 Shows the interpolation of the dataset where the linear equation is obtained:

$$V = 0.28 \times wate\_level - 0.11 \quad (1)$$

Hence:

$$wate\_level = (V + 0.11) / 0.28 \quad (2)$$

Where:

$$V = adc\_level\_value \times (3/4096) \quad (3)$$

TABLE.1: CALIBRATION OF SOIL MOISTURE SENSOR

Water level (cm)	Output voltage (v)
0	0
1	0
2	0.476
3	0.654
4	0.104
5	1.363
6	1.662
7	1.899
8	2.13
9	2.35

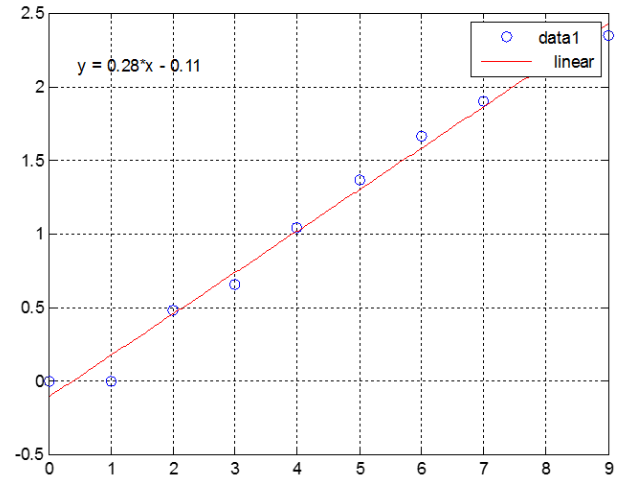

Fig.4. Inteploatin data set of the soil mosture sensor

2.3 Sensors of Telosb

Telosb has built-in sensors for environmental signals. These sensors are described as follows [19]:

A- Humidity sensor:

The environmental humidity can be found by:

$$humidity\,(\%) = -4 + 0.0405 \times (adc\_value) + (-2.8 \times 10^{-6}) \times (adc\_value)^2 \quad (4)$$

Where: adc_value: Convert digital humidity readout by Telosb ADC to humidity value.

B- Temperature sensor:

The environmental temperature can be found by:

$$Temperature\ (T_c) = -39.6 + 0.01 \times adc\_value \quad (5)$$

Where: adc_value: Convert digital temperature readout by Telosb ADC to temperature value.

C- Power equation:

This equation converting the ADC units to a voltage reading can be done with the following formula:

$$DV_{cc} = \frac{ADC\ counts}{4096} \times V_{ref} \times \frac{2R}{R} \quad (6)$$

Where: DV_{cc}: digital to voltage converter, ADC: analog to digital converter, 4096: 12-bit ADC, V_{ref} : reference voltage.

D- Light sensor :

The Telosb provides two light sensors, the HamamatsuS1087 for visible range measurements, and the S1087-01 for infrared range.

$$S1087\ Light\ (lx) = 2.5 \times (adc\_value) \ / \ 4096) \times 6250 \qquad (7)$$

3 PROPOSED IRRIGATION SYSTEM IN THE FIELD

The proposed smart irrigation is designed such that the Telosb nodes supported with four sensors, three of them have built in sensors which are Light, temperature, and humidity and one external sensor the soil moisture which has been used as a water level sensor. When nodes sense data it will build a packet. The packet will be sent to the base station. The base station will send packet to the PC through a USB cable where a middleware program written in python language will extract data from packets, such as temperature, water level, etc., and then it will upload this information to the cloud server. Data is Stored in a spread sheet. A website has been designed in the cloud server, which will display information Stored in the spreadsheet when a program in a java apps script is used to process this information. If any area has a drop in water level, then the system will send a command to the electrical valve in this area until the water level reaches the desired setting of level, Overall system as shown in Fig 5.

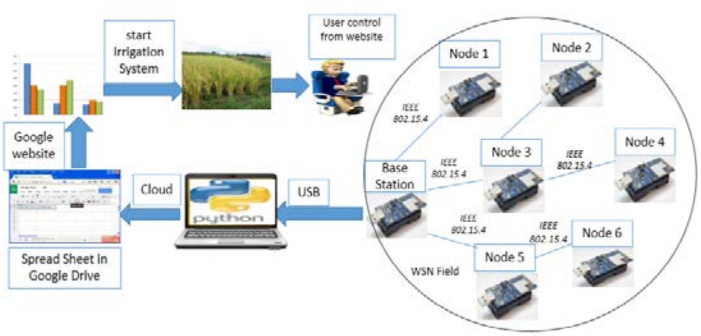

Fig.5. Overall proposed system

3.1 Description of Web Site

User can monitor and control the irrigation process from the website; it has been built by the language of JavaScript in Google Cloud as shown in Fig 6. From this web site we can enter personal information about farmers and can choose the type of crop in the farm.

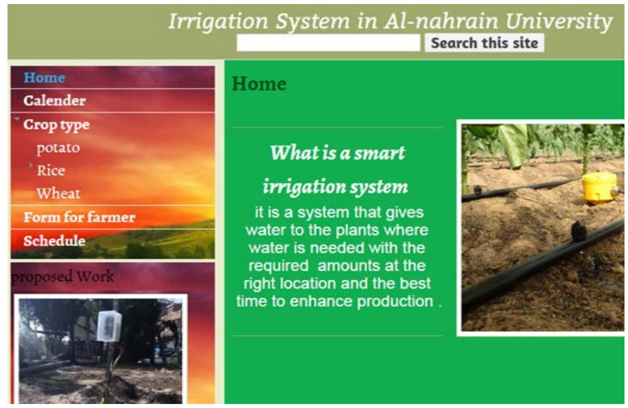

Fig.6. Home Page of the Web Site

4 CONCLUSION

Smart irrigation is an important technology in saving water for the plant which requires more attention especially in Iraq. Using WSN as an Internet of things gives more flexibility in system monitoring and management. Results show that the proposed network can be used along the season with minimum maintenance.

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