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A Low Cost Smart Irrigation System Using MQTT Protocol

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***Abstract*—In India agriculture plays a very important role.The Indian economy is also greatly affected by agricultural, as about 50 percent of total population is directly or indirectly depend on the agricultural related activities. A farmer has to go to the farm to check the water level in the field and to turn on and turn off the water pump, sometimes even in the middle of the night. This problem can be overcome by improving old methods of farming. A new system can be developed or designed which transform the old traditional farming into the smart farming. This paper tries to design a simple water pump controller by using a soil moisture sensor and Esp8266 NodeMCU-12E. A Message Queue Telemetry Transport protocol is used for transmitting and receiving sensor information. Depending on a status of soil moisture content NodeMCU-12E controls a water pump action and displays the soil moisture sensor data and water pump status on a web page or mobile application. In this way, a secure, flexible, trust-able and economical system is developed to solve above mentioned agricultural irrigation problem.**

I. Introduction

Internet of things enables an explicit interconnection between various machines, devices, and Internet-based services and also this technology also help further exploited to benefit people to do work easily. According to Indian government Internet of thing policy, they plan to invest 15 billion in IoT up to 2020. Indian government policy also states that amidst another thing, IoT also helps to automate solutions to problems faced by various industries such as agriculture, automobile, manufacturing, banking, retail, disaster management and more, through remotely connected devices. This will lead to an increasing Internet- connected devices from 200 million to 2.7 billion in India up to 2020. According to Gartner report, total revenue generated by IoT Industries would be 300 billion and connected devices would be 30 billion globally. It also assumes that India would have a share of 5-7 percent of global IoT industry market.

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Internet of thing has been providing its mettle across the industries such as agriculture, health services, energy, security, and banking. All the industries, one sector is rapidly increasing that is agriculture sector. The increase in an agricultural sector is due to an introduction of a concept of smart farming [19] [14],[15],[18] and digitalization. There are a wide range of IoT equipment available in the market for services like water resource management, tracking crop growth, smart route to detect pesticide spraying, high-tech laser-assisted precision land leveling, soil and plant monitoring [15], temperature, and humidity measurement [6],[9], remote control of pump sets in rural India and various other applications. But most of the pieces of equipment which are available in the market are costly and in a country like India where 80 percent of farmers are still small and marginal, buying this product for them is not economically viable.

In India farmer of small landholding has to travel at odd hours in the middle of the night or in the early morning to switch on and switch off the water pump when the power comes. The advantage of this system is that farmer can turn on and off the water pump by using Internet connectivity.In this system soil moisture sensor used [4],[8]for measuring the water content in the land and depend on water content pump state will decide, so there is no need of manually turn on and off of the water pump it automatically does by the server. In this project, we used the thinger.io platform for display soil moisture value and relay position in a web page and mobile app. We also used thinger.io platform extra features like a map, Donut chart, progress bar, and serial chart.

Nowadays people are using IoT devices in homes, Agriculture[11], cars, industries, and many other places, so it is needed that our physical security and privacy should be maintained. In thinger.io platform inbuilt security provided by using Transport Layer Security (TLS) and Secure Socket Layer(SSL) cryptographic protocols and it is easily disabled also by using simple commands.

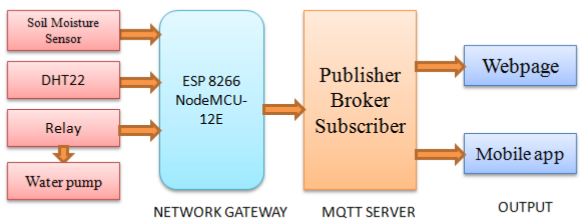

Fig. 1. SYSTEM ARCHITECTURE

II. DESIGNING AND IMPLEMENTATION

The above diagram shows the system architecture of the project. The Agriculture based water pump is designed with on/off the controller and Esp8266 NodeMCU-12E using MQTT protocol. Esp8266 NodeMCU-12E is connected to the Soil moisture sensor and relay. Esp8266 NodeMCU-12E is then connected to the MQTT server which is used for the display purpose. The soil moisture sensor measures the data and that data is sent to the user via MQTT server. The given project basically has two sections. The first section consists of sensor and relay and the second section consists of MQTT-thinger.io and displaying the obtained results. In the first section, the Esp8266 NodeMCU-12E [5] which is used as a network gateway is connected to soil moisture sensor and relay using wired connection.

The first aspect of project includes the testing and checking of the soil moisture sensor, relay, and Esp8266 NodeMCU-12E. In the second aspect, the user initially does the primary procedure of MQTT-Thinger.io. In it the user installs Thinger.io library in Arduino-IDE and it is tested and checked by simple inbuilt examples and also it also tests that message being transmitted and received is correct between the publisher and the subscriber component [5]. So whenever the soil moisture sensor measures the data, that data is sent to the Esp8266 NodeMCU-12E.The user can now view the topics to which the user has subscribed like the soil moisture sensor value and water pump state using the above-mentioned method. For security purpose in Thinger.io platform has inbuilt security protocols such as TLS and SSL. The final stage involve database handling, an introduction of logging methods by creating username (userid) and password for accessing the data. In short, by using this measures we can strengthen the entire MQTT system which makes it desirable to use these measures. Then finally the data is displayed using the webpage and mobile application.

III. METHODOLOGY

The proposed system's objective is mainly to collect the data from the sensors and send this data to the user whenever the user wants to check the required soil moisture and water pump status. The Esp8266 NodeMCU-12E acts as a gateway server for connecting to the Internet. It acts as a small network having control over the sensors which give the updates of the soil moisture values, water pump state and the status of the components. The data is secured using security Protocol (secure socket layer).We have used a soil moisture sensor [4] (which measures both analog and digital values) and a two Channel Relay Module (5V, 10A) for our project. Moreover, the data is stored continuously in MQTT Server. The advantage of using MQTT protocol and transport layer security (TLS) cryptographic protocol is that no ambiguous data is stored along with the required data.

IV. ESP8266 NODEMCU-12E AND SENSOR

A. *ESP8266 NoDEMCU-12E*

NodeMCU is the more popular development board for the vastly popular Wi-Fi Internet of thing chip from Espressif, the ESP8266. It uses the Lua scripting language to make it simple to run user programs on the ESP8266 without any recompilation. The board consists of an ESP-12E module, CP2102, and USB connector for power. All the pins of the ESP-12E are brought out on compact and narrow board design to make it breadboard friendly.we can use the nodemcu firmware or the Arduino development environment [5].

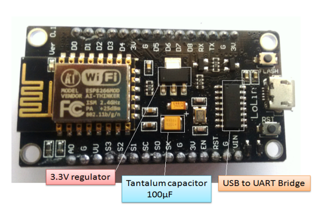

Fig. 2. ESP8266 NoDEMCU-12E

TABLE I
FEATURES OF ESP8266 NODEMCU-12E

Name	Specification
Flash memory	4M
Scripting language	2 buttons (reset and flash)
GPIO pins	17 GPIO
ADC	1 - 10 bit
Operation modes	sleep,Deep sleep and Active modes.
Operating voltage	3.3 V
Internet	IEEE 802.11 b/g/n Wi-Fi
programmer	CP2102 USB-to-UART
module	ESP-12E

B. Soil moisture sensor

Soil moisture sensor is a low cost and user friendly device, which is used as to detect soil moisture value [4],[12].Different crops required the different level of moisture [19] so that productivity increases [17].By using soil moisture value, farmers should know about how much water is present in the farm [16],[7].Human intervention is not needed. In soil moisture sensor is low power device operated in 3.3V-5V.soil moisture sensor has both digital and analog outputs [20].

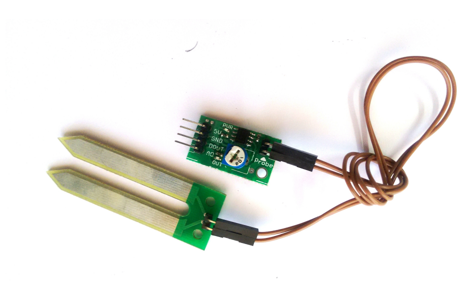

Fig. 3. Soil moisture sensor

TABLE II
FEATURES OF SOIL MOISTURE SENSOR

Name	Specification
Power indicator	Red color led
Digital switching output indicator	Green color led
Comparator	LM393 comparator
Operating voltage	3.3V-5V
Digital output interface(0 and 1)	DO
Analog output interface	AO

C. Relay

The relay is the switch (turn on and off) which operates electrically or electromagnetically [5]. In this paper, the relay is used for turn on and off the water pump.

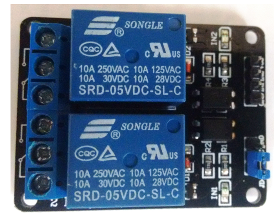

Fig. 4. 2 Channel relay

TABLE III
FEATURES OF RELAY

Name	Specification
Relay Contact Current Capacity	AC250V: 10A
No of relays	2
Max current for each relay	20mA
Operating voltage	5V
Relay Contact Current Capacity	DC30: 10A

D. DHT22

DHT22 is more accurate, low cost and more precise temperature and humidity sensor. DHT22 has an ability to collect digital signal with humidity and temperature sensing technology. This sensor consumes less power and produces output reliable and stable.

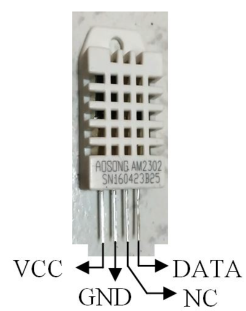

Fig. 5. DHT22

TABLE IV
FEATURES OF DHT22

Name	Specification
Interchangeability	possible
Humidity range(percentage)	0 - 100
Temperature range(deg. Celsius)	40 to 80
Operating voltage(Voltage)	3.3 - 6

V. MQTT PROTOCOL

There are several protocols used in IoT for Device to Device (D2D) Communications, such as MQTT, COAP, DDS, AMQP, and XMPP [3],[9].

MQTT is the Message Queue Telemetry Transport protocol [3],[10]. It basically Follows publish/subscribe architecture [3], and the system consists of Three most Important key component-Publisher, Broker, and Subscriber [5],[2].The Publisher is the sensor which is used for sensing data and sends this data to the broker for processing purpose and if not needed then go to the sleep mode. The broker is sending that information further [3],[2]The subscriber is the application based and connected to the broker[5]. If new data come to the broker then the broker will inform to the subscriber.

VI. Hardware and Software Aspect

As shown in fig.5,relay is connected to Esp8266 NodeMCU-12E model and also soil moisture sensor. Esp8266 NodeMCU-12E model has one analog reading GPIO pin which is A0,so soil moisture is connected to A0.Relay is connected to GPIO 13pin which is D7 in Esp8266 NodeMCU-12E model and bulb is also connected to relay.In hardware design the bulb is in on state indicates the water pump is on state and the bulb is in off state indicates the water pump is off state.The DHT22 temperature sensor is connected to a D2 pin of ESP8266 Nodemcu, which is used for measuring the temperature and humidity in the environment.

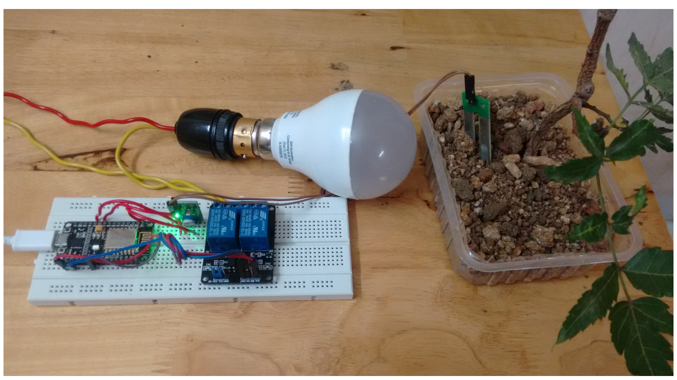

Fig. 6. Circuit Connections of the system

Esp8266 NodeMCU-12E model supports Lua programming language. In this paper, broker is the thinger.io, which is user-friendly and giving various features. In this paper Arduino-IDE platform used for designing the proposed system. Arduino-IDE supports thinger.io library and itâĂŹs very simple to write a code in Arduino-IDE [3] and design system.

VII. Results

As shown in Fig.7, soil moisture value in percentage, temperature, humidity and water pump state displayed on the webpage, also the location of Esp8266 displayed by using Google map.The value of soil moisture with respect to time also displayed.Fig.8 shows the state of the water pump and soil moisture value in percentage in the mobile application provided by thinger.io.

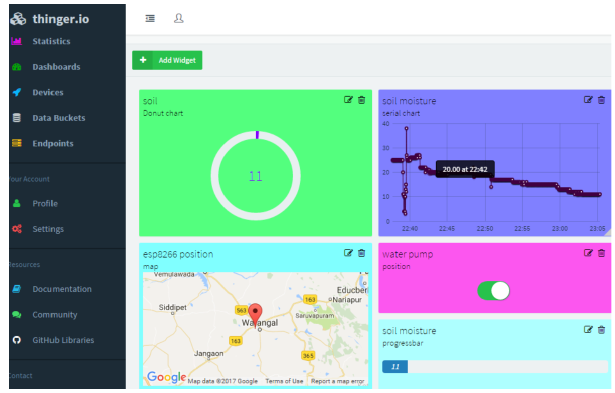

Fig. 7. soil moisture value and pump state display in webpage (thinger.io)

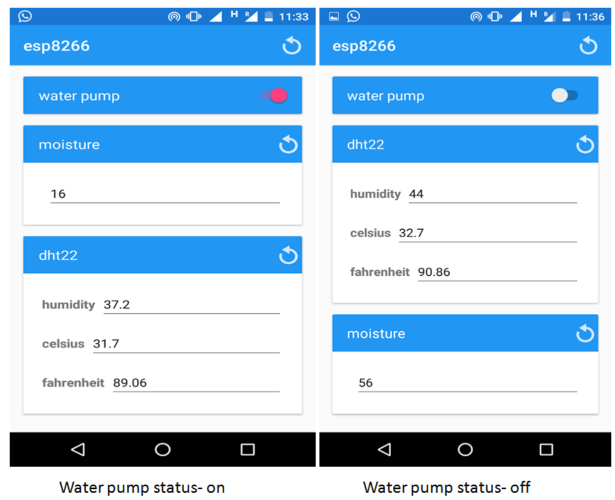

Fig. 8. soil moisture value and pump state display in mobile application (thinger.io)

VIII. Conclusion

In this given project we have tried to make a simple water pump controller, based on the soil moisture sensor and using Esp8266 NodeMCU-12E which is useful in the agriculture field. For given system security provided by using Transport Layer Security (TLS) and Secure Socket Layer (SSL) cryptographic protocols. Esp8266 NodeMCU-12E is low cost, low power consumption, small size microcontroller which makes proposed system appropriate for given application. The high precision soil moisture sensor provides analog reading, so we correctly measure soil moisture value. Finally, we displayed soil moisture value and water pump state in mobile app and webpage.

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