An IoT based soil moisture monitoring on Losant platform

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An IoT Based Soil Moisture Monitoring on Losant Platform

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***Abstract*—The Internet of Things (IoT) is converting the agriculture industry and solving the immense problems or the major challenges faced by the farmers todays in the field. India is one of the 13th countries in the world having scarcity of water resources. Due to ever increasing of world population, we are facing difficulties in the shortage of water resources, limited availability of land, difficult to manage the costs while meeting the demands of increasing consumption needs of a global population that is expected to grow by 70% by the year 2050. The influence of population growth on agriculture leads to a miserable impact on the farmers livelihood. To overcome the problems we design a low cost system for monitoring the agriculture farm which continuously measure the level of soil moisture of the plants and alert the farmers if the moisture content of particular plants is low via sms or an email. This system uses an esp8266 microcontroller and a moisture sensor using Losant platform. Losant is a simple and most powerful IoT cloud platform for the development of coming generation. It offers the real time data visualization of sensors data which can be operate from any part of the world irrespective of the position of field.**

I. INTRODUCTION

Food production takes up almost half of the planets land surface. About 40% of the earths land is now given over to agriculture, and it consumes 85% of available fresh water. Due to globalization and population growth this figure of water conservation has been increasing every year. So it became a major challenge to every nation for reducing the farm water consumption. For better irrigation system, it is very crucial to measure the soil moisture for agriculture application, so that it will help farmers to manage their farm land more effectively.

IOT is the technology that enhance the Internet connectivity from digital devices to physical objects and establishes communication between them. The data collected are stored and managed at the cloud as well as shared between person to person, machine to machine, or person to machine. The invent of IoT would discover the new ways that put full potential of agriculture yield and mitigate the challenges that hinders the growth of crops. With the IOT, the monitoring of weather forecast, soil temperature and humidity, soil moisture level, remote water valves, pest control could be connected and information gathered from the sensors is exchanged to the farmers via mobile phones. Soil moisture is an important component on a small agriculture scale as well as large agriculture scale modeling. Vegetation and crops mainly depends on the root level of moisture present in the soil. Knowledge of degree of soil wetness helps farmers to understand the condition of field and accordingly they react on it. Soil moisture determines the measure of soil water content which defines its expression in terms of mass or volume of water content of the soil. On the basis of mass, soil water content is expressed in the gravimetric soil moisture content θg [9]is given by:

$$\theta g = Mwater/Msoil, \tag{1}$$

where Mwater is the mass of the water in the soil, and Msoil is the mass of the dry soil present in the field.

The volumetric soil moisture content of a soil θv,is defined by:

$$\theta v = Vwater/Vsample \tag{2}$$

where Vwater is the volume of water content in the soil and Vsample is the total volume of dry soil +water+ air present in the sample of field.
Both the values θg and θv are usually expressed in percent. The relationship between the gravimetric soil moisture content and volumetric soil moisture content is:

$$\theta v = \theta g(\rho b/\rho w) \tag{3}$$

where ρb is the dry soil bulk density and ρw is the soil water density.

Over irrigation of the plants may perish the plants roots of oxygen and causes them to putrefy and it leads to soil fungal diseases [3]. Research has been done that about 80% of the crop is destroyed due to over irrigation, which reduces the growth of crops yield. On the other hand, sometimes due to scarcity of water, field become dry and the plants will not receive enough nutrients for the growth of crops. To satisfy the increasing demand for determining the soil moisture status, IOT and use cases play a vital role in the field of agriculture industry. One of use case we implemented and tested by deploying moisture sensor in the sample of pot. The sensor data feeds to the Losant cloud platform interface to help the intended persons make timely decisions. Data is available instantly in the App to view the moisture level anytime or anywhere in the world.

II. LITERATURE SURVEY

Monitoring of volumetric soil moisture content of the field is a significant factor for the pavement performance. Understanding the effects of the soil moisture on performance is crucial. This paper [1] proposed a system for monitoring the soil moisture using homemade soil moisture sensor and Arduino Uno board. The eminent feature of this system is to measure the soil moisture along the depth which can determine the time of water supply to reach the crop roots. This improves the cost efficiency and water resources management.

This paper[2] shows the analysis of different types of moisture sensor compared to the different types of soil. It includes sensors like commercialized soil moisture sensor, galvanized steel nails and gypsum block and soils taken in experimentation were silt oil, clay soil, sandy soil. After analysis it describes that for real or actual implementation the combination of these three types of soil with different proportion ratio of each soil is best soil for plant growth.

Nowadays, many garden centres uses a timer-controlled sprinkler which automatically supply the water to the plants irrespective of the content of moisture present in the soil that leads to over irrigation of plants. This paper[3] present a system that is capable of measuring the soil moisture of the soil. It uses a Teensy 2.0 micro-controller with a dual output tap timer. Thus the plant will supply water whenever the content of moisture in the soil becomes low.

Watering is the most important aspect in the growth of plants. Thus water should be supply at the right time whenever required by the plants. This paper[4] proposed an automatic plant watering system by using sprinkler systems, pipes and a nozzle. For the control of the whole system an ATmega328 micro-controller is used and it programmed in such a way that it sense the moisture level and water according to them. So conservation of water is possible by this approach.

This approach[5], [6] design a wireless sensor network using an arduino with a grove moisture sensor and water flow sensor. It uses a zigbee protocol for the communication among them and the status of the system will be displayed on web portal. The intimation about the water flow will also sent to the users phone using GSM.

The approach given in this paper[7] is to developed a system for monitoring the soil moisture content of soil by using IOT, mobile computing technology and cloud computing. CC3200 launch pad is interfaced with a soil moisture sensor and data is stored in the AT&T M2X cloud technology and blynk application is used in android phone by the user to check the status anywhere and make timely decision.

III. DESIGN AND IMPLEMENTATION

The overview architecture of the proposed system is shown in Fig.3. In this system nodemcu board which acts like a client publishes the sensor data into the Losant Message Broker using the MQTT protocol on to the topic losant/DEVICE_ID/state. In order to understand the messages of losant, a defined json-based payload must be followed. The published data will automatically store in the losant and make it available in visualization tool of losant platform. In order to subscribe the stored data from the losant MQTT broker the client must subscribe to the commands that are initiated using losant workflow on to the topic Losant/DEVICE_ID/commands.

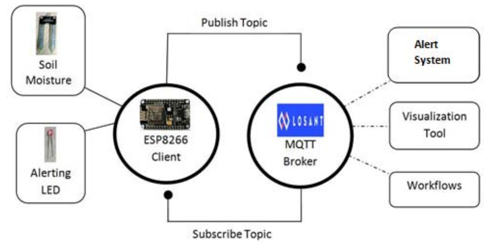

Fig. 1. Block Diagram of Soil Monitoring System

A. NodeMCU V1.0:

NodeMCU V1.0 is an open source IoT platform with ESP8266-12E chips. It is low-cost, breadboard friendly, integrate a USB to serial chip, and a simple USB to micro USB cable can be used to powered this board. This modules aimed for developing ESP8266 based Lua IoT applications and it includes firmware that runs on the ESP8266 wifi SoC from Espressif system. This development board provides access to the GPIO(General purpose Input/Output) subsystem. Based on ESP8266 there are jungle of available modules and every module has certain advantages and disadvantages, depending on the targeted application. The following table gives the comparison of some of the ESP8266 modules:

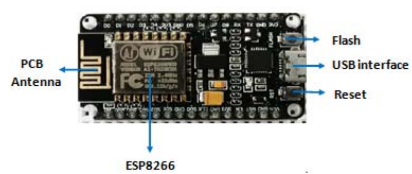

Fig. 2. NodeMCU board

B. Moisture Sensor

Soil moisture sensor is used for measuring the volumetric water content of the soil and loss of moisture which occurs due to evaporation and plant uptake. For survival of all plants, water is the most important factor. This soil moisture sensor determines the amount of water required for irrigation of plants. This module consists of LM393 comparator with a potentiometer included in it for adjusting the soil wet/dry detection sensitivity according to the requirements of plants.

There are two types of soil moisture sensor: Frequency domain sensor and neutron moisture gauze. Frequency domain sensor has an oscillating circuit which measures the soil water content. The basic principle is that it measures the soils dielectric

TABLE I
TECHNICAL SPECIFICATION OF WEMOS

FEATURE	NodeMCU V0.9	NodeMCU V1.0	Wemos D1 mini	WemosD1 R2
Branded	NodeMCU	DOIT	Wemos	Wemos
GPIO pins	11	11	11	11
ADC	1	1	1	1
Antenna	PCB	PCB	PCB	PCB
ESP8266 module	ESP12 (AI-Thinker)	ESP12E (AI-Thinker)	ESP12E (Wemos)	ESP12E (Wemos)
USB to Serial	Yes	Yes	Yes	Yes
Serial Chip	CH340G	CH2102/CH340G	CH340G	CH340G
Breadboard friendly	Bad(covers many pins)	Very Good	Very Good (after Soldering)	Bad
Form factor	Big	Big	Medium	Very Big
Price	$\sim$ \$6.40	$\sim$ \$6	$\sim$ \$6	$\sim$ \$6.50
Application	Development Beginner	Development Beginner	Development Advanced (soldering Required)	Development Form compati-bilty with arduino shields

constant which determines the velocity of electromagnetic wave through the soil. When the soils water content increases, the dielectric of soil also increases which can be used to estimate how much amount of water the soil holds. Other one is neutron moisture gauze, that works on the moderator properties of water for neutrons. The basic principle is that fast neutrons are emitted from the decaying radioactive source, and when the collision occurs between neutrons and protons, they slow down dramatically. By measuring the density of slowed-down neutrons around the probes of moisture sensor can estimate the volumetric content of water the soil holds.

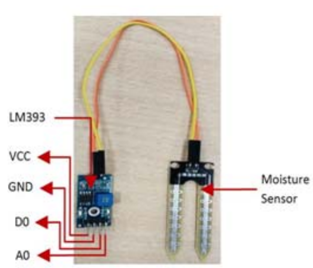

Fig. 3. Moisture Sensor

1) LM393 Driver: LM393 comparator is used to compare the soil moisture level with the preset threshold value. This device consists of two independent low voltage comparators which is designed specifically to operate over a wide range of voltages from a single power supply. The unique characteristics of these comparators is that the input common mode voltage range includes ground even though operation is done from the single power supply voltage. It is available in DIP8, SO-8, TSSOP8, miniSO-8, and DFNB 2*2mm packages. Some features of this device is given in Table III:

TABLE II
PIN DEFINITION

PIN	DEFINITION
VCC	Power supply
GND	Ground
D0	Digital Output interface(0 or 1)
A0	Analog Output interface

TABLE III
TECHNICAL SPECIFICATION

Wide single supply voltage range or dual supplies	+2V to +36V or $\pm$1V to $\pm$18V
Low Supply current	0.45mA
Low input bias current	20nA
Low input offset current	$\pm$3nA
Low input offset voltage	$\pm$1mV
Low output saturation voltage	80mV

IV. LOSANT

Losant is a simple and powerful IOT cloud platform that makes building real-time connected solutions a breeze. It provides connectivity from one to billions of devices by using open communication standard like MQTT and REST and help in turn raw data into insight. The data are fully encrypted using the industry standard TLS(Transport Layer Security) encryption protocol. Losant provides robust data collection, aggregation, visualization and graph our path with real time device states and sensors data. Losants drag and drop workflow editor allows us to trigger actions, notification and M2M communication without using programming. MQTT is a lightweight preferred communication protocol that easily wrap up the communication between our devices and the Losant platform. The core concept of MQTT protocol is publishing and subscribing to topics by the clients via the central service called message broker. Clients can publish any data they prefer to any topics they select. Others clients then subscribe to those topics to retrieve that data. In order to support existing MQTT implementations, Losant provides an MQTT message broker that will be open for all the clients and it is responsible for properly routing messages to the subscribers. Losant message broker can be reached using several transport protocol like TCP, TLS, Websockets, Secure Websockets. Losant provides an opinionated MQTT implementation for further features of Losant like data collection, visualization, and workflow.
Connecting with Losant platform is very easy and it took 4

simple steps which are as follows:

• Create an Application: An application is created by some meaningful name which contains all the devices and workflow that makes us convenient to connect us with the real world.

• Add a Device: In Losant a device is a single thing or widget. It could be anything from a simple car, smart devices, thermostat to any kind of custom gadgets.

• Create a Workflow: Complex interactions between our devices and 3rd party system can be easily build by simply using drag and drop workflow editor. Its output can also be used to track data by storing it in virtual device.

• Create a Dashboard: Losant platform provide a flexible and powerful way to visualize and analyze the data we stored in our device. This dashboard generator is used to display the information relevant to our specific connected solutions.

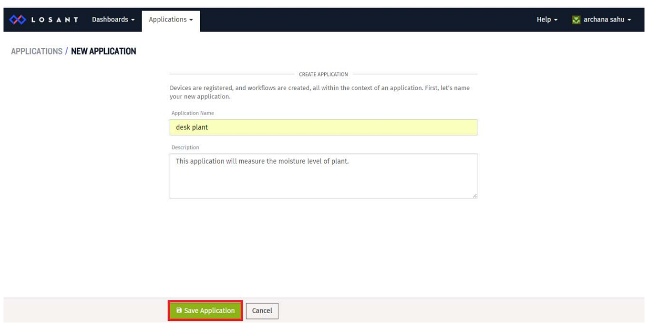

Fig. 4. Creating Application

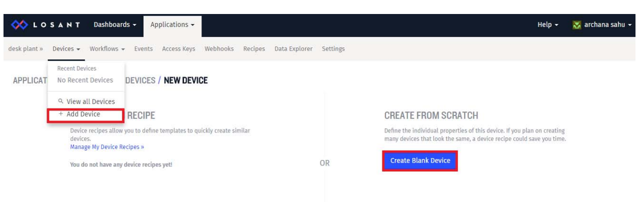

Fig. 5. Adding Device

V. Hardware Realization

Moisture Sensor Kit is realized using NodeMCU development board having an ESP8266 WiFi module mounted on it and a pre-wired soil moisture sensor module. The soil moisture sensor module connected with LM393 comparator, gives an active-high(H) level output when the soil is dry. This digital output (dry soil-H / wet soil-L) is routed to one of the I/O terminal (A0) of the nodeMCU micro-controller. Based on this input (at A0) nodeMCU gives an active-low output through D1 when the soil is wet, and an active-high input when the soil is dry. Using male-to-female jumper wires connections can be established. Wiring diagram is shown in the fig: 8. A micro USB cable is used in nodeMCU board for power supply. In Losant platform while creating a new device, the device ID is generated. This ID is required in software part. For the authentication of our device against the Losant platform some security keys need to generate that provides access to all the devices in our application. This keys are also required in programming.

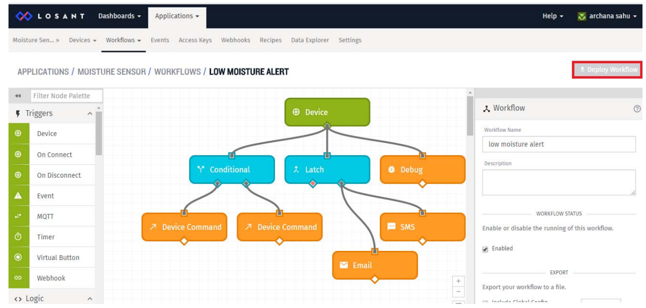

Fig. 6. Creating Workflow

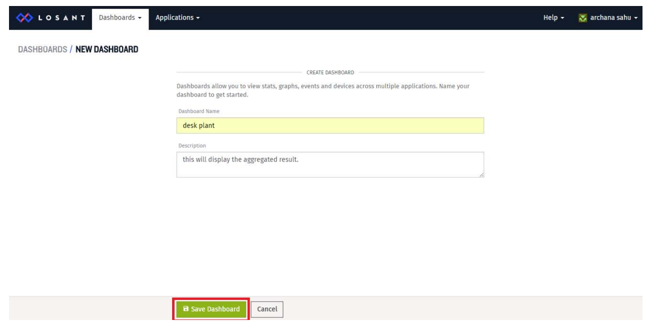

Fig. 7. Creating Dashboard

TABLE IV
Soil Condition with its LED Status

Soil Condition	LED status
Wet	LOW(L)/OFF
Dry	HIGH(H)/ON

VI. Software Realization

For all Losant IoT developer kits an environmental setup must be done before flashing the firmware into the device. An USB drivers is installed in the Arduino IDE. For this workshop a few libraries require to be installed. The required libraries are PubSubClient, ArduinoJson and Losant Arduino MQTT Client. After the environmental setup a Moisture Sensor firmware will be flashing to the device. In the kit source code few things need to be modified such as

Fig. 8. Circuit Connection.

wifi_SSID, wifi_pass, Losant_Device_ID, Losant_access_Key, Losant_access_secret. Now upload the firmware to the device and after every 60 seconds the firmware is publishing the state of moisture value to the losant. The moisture values varies between 0-1024 that the micro-controller ADC is providing. Higher values means less moisture and lower values means more moisture.

VII. TESTING AND RESULTS

The complete hardware and software setup have been done to monitor the soil moisture of the field. We have tested in a small scale by inserting a moisture sensor and visualize the readings. In order to view the results in Losant platform, a dashboard is created named desk plant. A gauze block and a time series graph is being customized to view the moisture level over time as shown in fig: . We have import workflow in Losant platform to setup an alerts via SMS or an email to the intended person. This alerts will be active whenever the moisture level of the plants will be less and we are being notified by SMS or email as shown in fig:10 as well as the board will subscribe to the commands back from the losant to turn on the LED if the percentage of moisture in the soil is below the threshold value.

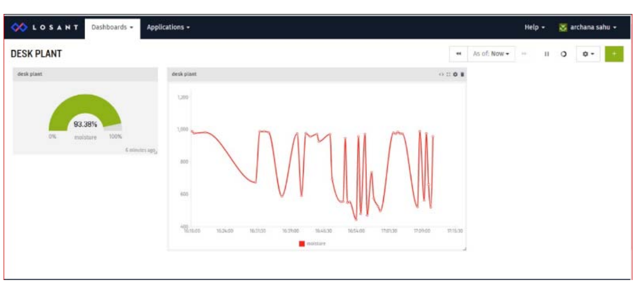

Fig. 9. Screenshot of gauge block and time series graph view.

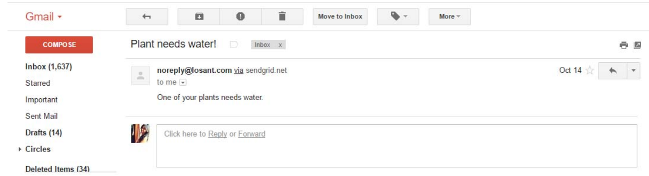

Fig. 10. Screenshot of an alert email.

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