Plant Monitoring Systems- an IoT-based Project

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1 Abstract

The Internet of Things (IoT) refers to a network of physical objects embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet.

2 Introduction

Internet of Things (IoT) refers to a network of physical objects embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet.

The goal is to build a smart farm that is capable of controlling and monitoring its surroundings to maximize plant development. The farm should be able to monitor the PH level, maintain appropriate soil humidity levels, and modify its moisture content in accordance with the current conditions.

In other to accomplish this therefore, the Smart farm will have the appropriate sensors and actuators installed, and it will be linked to a central server via the MQTT protocol to provide real-time control and monitoring.

2.1 Motivation

2.2 System Overview

The goal of this Internet of Things system is to use sensor data to automate watering and monitor soil conditions. The pH and moisture content of the soil can be monitored by the system using an Arduino-based microcontroller coupled with a humidity and pH sensor. The water pump is managed by a servo motor that communicates to a Raspberry Pi by a broker network.

Upload the images showing how different sample rates affect the wave

3 Concept Draft

The Sensor node: The sensor network is made up of;

DFRobot Gravity PH sensor: It is an analog sensor with Analog to Digital Converter(ADC) connected to a probe. The probe is inserted into a solution, in other to read the PH value. The signal pin is connected to A0 pin of the Arduino wifi-rev2, as a client. It needs between 3.3 to 5.5 volt input, with dedicated library.

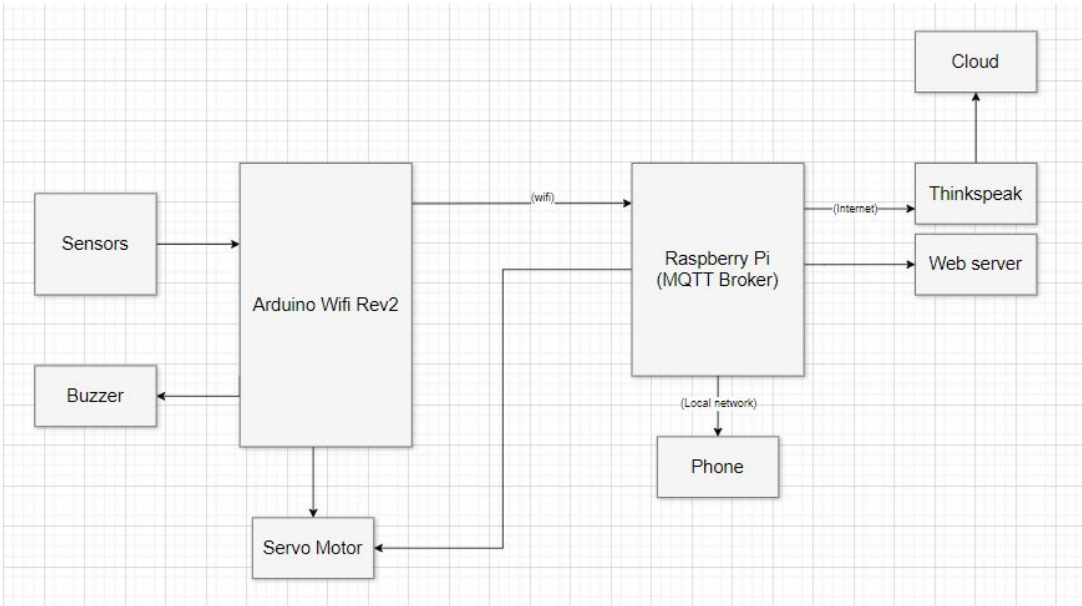


Figure 1: Concept Design

Moisture sensor: The simple resistive moisture sensor when immeresed in the soil, measures the percentage moisture level. It accomplishes this by analyzing the electrical resistance between two probes inserted into the soil. The resistance changes as a function of soil moisture content.

Dry soil exhibits high resistance between probes due to poor electrical conductivity, while wet soil exhibits low resistance due to water's ability to facilitate current flow.

Hence, the Arduino reads the voltage signal that the sensor produces after measuring resistance. The moisture content of the soil can be estimated by the microcontroller by interpreting this signal as shown in the code below.

Actuator (servo): The servo motor tied to the water pump is operated by the Raspberry Pi. When necessary, the servo motor receives orders from the sensor to pump water, ensuring that the soil moisture content is optimum.

A servo is an electric motor that can accurately regulate torque, speed, and angular or linear position . The control signal is commonly a pulse width modulation (PWM) signal, which indicates the intended position of the servo motor's output shaft. The DC or AC motor spins in the appropriate direction based on the feedback system's reactive signal.

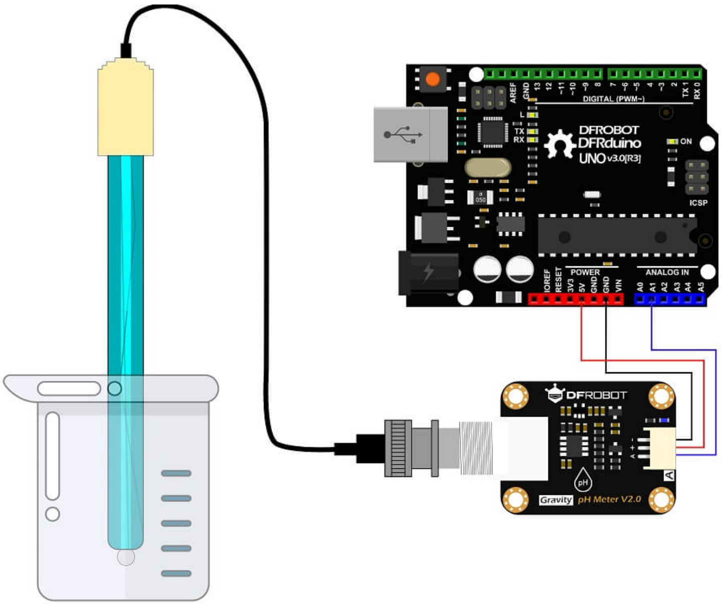
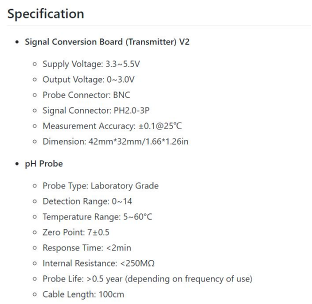


Figure 2: PH Sensor



Specification

- **Signal Conversion Board (Transmitter) V2**
  - Supply Voltage: 3.3~5.5V
  - Output Voltage: 0~3.0V
  - Probe Connector: BNC
  - Signal Connector: PH2.0-3P
  - Measurement Accuracy: ±0.1@25℃
  - Dimension: 42mm*32mm/1.66*1.26in
- **pH Probe**
  - Probe Type: Laboratory Grade
  - Detection Range: 0~14
  - Temperature Range: 5~60°C
  - Zero Point: 7±0.5
  - Response Time: <2min
  - Internal Resistance: <250MΩ
  - Probe Life: >0.5 year (depending on frequency of use)
  - Cable Length: 100cm

Figure 3: PH Sensor Datasheet

4 Project/Team management

The initial project was organised using a top-down approach, in other to conceptualise the main idea, during the initial lab series. We further iteratively accelerated the project employing a scrum model. Each week, our sprint is aimed at breanstorming on present task and getting it done as soon. The overall team progress is reassessed after each sprint, and documented by the project lead. The overall team lead is structured, but the lead on each weekly meeting is varied according to the sprint task. This is because, each member takes on a mini-lead role in certain task such that he research deeply in while we all meet and brainstorm on them before the next sprint. In this case, he leads the session, while others colaborate.

5 Technologies

There are several technologies central to the overall project. These may include;

Wireless Sensor network A wireless sensor network is made up of a number of separate, autonomous sensors, or "nodes," that link to one another wirelessly.

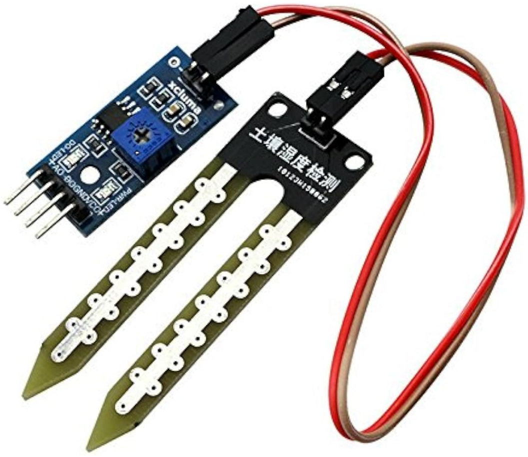


Figure 4: Moisture Sensor

Figure 5: Servo Motor

Communication via wireless networks is a fundamental component of a WSN. In this setup, sensor data is sent electronically from the Arduino to the Raspberry Pi via a Wi-Fi module (the Arduino Wifi-Rev2). This wireless data transmission is made possible via the MQTT protocol, which enables real-time communication between the Raspberry Pi broker and the sensor nodes, which are pH and humidity sensors connected to the Arduino wifi.

PH Sensor Node: Reports the soil's pH level.

Humidity Sensor Node: Tracks the percentage of moisture in the soil.

Arduino

Python Python scripts were written on the Raspberry pi in other to establish effective communication in the system. **MQTT** MQTT(Message Queuing Telemetry Transport—) is a lightweight messaging protocol suitable for networks with unstable or low bandwidth and high latency. Its effectiveness and simplicity of use make it a popular choice for Internet of Things applications. Its key function in the project;

As a broker; it stands as central server that distributes messages. For instance, publishers provide messages to it, and it forwards them to subscribers and vice versa. PH ans moisture level are both sent as published messages(PHTopic and MoistureTopic) to subscribers. The detailed flow is shown on the codes and github. The connection(publishers/subscribers) is made possible with TCP/IP. We connected the broker via its ip address (172.20.10.10) unto the mqtt server, through port 1883.

Raspberry Pi

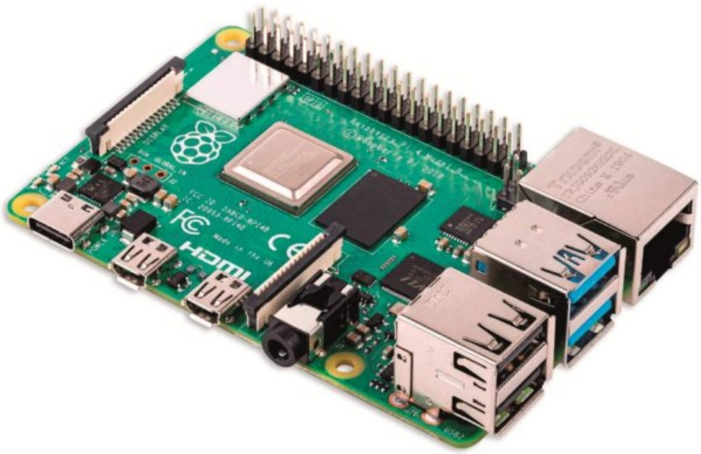


Figure 6: Raspberry pi

6 Implementation

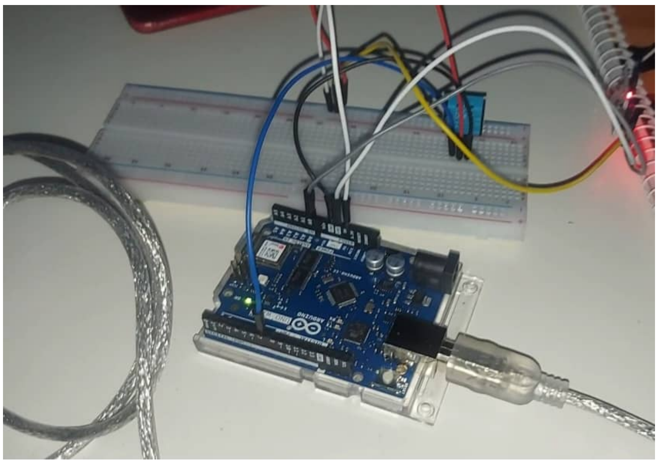


Figure 7: Arduino connections

Client and access points

Database

Broker: The broker netWork was realised in other to establish a wireless communication between the clients and server. It therefore transmits data between them as shown below. The result is equipped with an external screen designed for data visualisation dashboard.

Cloud Services While we could read the corresponding data outome on the dashboard, we could equally visualise it remotely via cloud service. There are several cloud services, but we chose Thinkspeak. It offers connection using MQTT and POST protocols. We need the credentials of the Thinkspeak channel to connect. The credentials include API Write and Read keys, MQTT username and password, as well as channel ID.

7 Use Case

The system was tested in a modular form before being deployed collectively. The PH was caliibrated effectively for the 4 solution and 7 solutions, and reported accurate readings. This could be a very important system in fish farming. Some fishes in their early stages are very sensitive to water concentration. Acidic water usually results in high mortality at this stage, unlike in later stage. Getting an accurate PH becomes very important after cleaning up the pond. It can equally be used in real time to decide when pond needs to be sanitised.

Finally, we equally tested components of varied soluble contents like water and soil types.

Observation:

The readings is more stable when reading soluble constituents like water. However, we obtained an accurate arable soil PH readings of slightly alkalinity between 7.2 - 8.5, but are less unstable than that of water and solution 4 and 7.

7.1 Limitations

While the project has demonstrated its effectiveness in monitoring and regulating plant environment, we observed that the use of the PH sensor is most adapted for soluble solutions.

To be adapted for soil PH measurement therefore, it would be most recommended to measure a soluble soil sample as possible, and calibrated accordingly. These findings creates a room for further research into a more test cases and use cases of this system.

Test results, scenarios and explanations. How the system is supposed to work

8 Sources/References