IoT Platform-Based Sprinkler for Potato Plants

Maksy Sendiang, Anthoinete Waroh and Anthonius Manginsela
Manado State Polythectnic, Buha, Kec. Mapanget, Kota Manado, Sulawesi Utara, Indonesia

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Abstract: In order to develop successfully, potato plants require the right amount of soil moisture. Manually watering plants frequently causes excess or insufficient water to affect the plants, resulting in growth failure. Plant sprinklers that operate automatically are the answer to this issue. An ESP32 microcontroller serves as the controller, together with a number of sensors, including an ultrasonic sensor, a soil moisture sensor, and a real-time clock. This device is connected to the IoT platform e.g thingsboard, in order to monitor and see the sensor status. This device appears to function as predicted based on test results from many scenarios.

1 INTRODUCTION

Plants will take up enough water from the soil to support their growth. The plants will wither if the soil is too dry and its moisture level falls too low. Similar to the last example, too much water in the soil will lower oxygen levels and trigger root respiration, which reduces root volume and raises resistance. to produce harmful chemicals and carry water and nutrients through the roots. Water must therefore be provided in the proper quantity because it actually promotes plant growth (Sitti Nur Farida et al, 2014).

The task of watering plants is done in an effort to preserve the water content of the soil, which serves as a reservoir for plant growth. Due to the fact that it is typically done by hand, watering plants is one of the mundane and routine tasks. Because sprinklers only rely on visual abilities to determine the amount of water provided to plants, manually watering plants has challenges. Additionally, carelessness elements cannot be avoided and they all frequently affect plants over time by depriving them of water or even overwatering them. The incorrect technique or method of watering plants nearly always has an impact on factors that determine the failure of a plant's growth (M. Irsyam, 2019). Excessive watering will cause the plants being looked after to become sickly and incapable of thriving.

One of the cultivated plants that can thrive between 500 and 3000 meters above sea level in tropical and subtropical regions is the potato. Potatoes can grow best in the tropics at a height of 1300 meters above sea level. For potato plants to thrive, soil must be rich in nutrients, loose, and well-drained. Potato plants grow well in loose clay, silt, or sand dust with a pH range of 4.5 to 8. The pH range between 5 and 6.5 is ideal for potato plant growth and yield; with a pH below 5, potatoes will produce poor-quality tubers that are vulnerable to scurvy. Potato plants' development and yield are impacted by the climate. Temperatures between 15 and 20 degrees Celsius, enough sunlight, and 80% to 90% humidity are ideal for potato growth. (Nugraeni Ratna Widiastuti, 2020).

2 LITERATURE REVIEW

2.1 ESP32

A single 2.4 GHz Wi-Fi and Bluetooth combination chip called the ESP32 was created using TSMC's ultra-low-power 40 nm technology. It is made with the best RF and power performance in mind, and it exhibits resilience, adaptability, and dependability in a number of power scenarios. The ESP32 is made for Internet-of-Things (IoT) and wearable electronics applications. According to the ESP32 datasheet, it has all the cutting-edge attributes of low-power processors, such as fine-grained clock gating, numerous power modes, and dynamic power scaling (ESP32 datasheet).

With about 20 external components, ESP32 is a highly integrated solution for Wi-Fi and Bluetooth

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IoT applications. An antenna switch, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules are all integrated into the ESP32. The ESP32 Module's physical form is as follows.

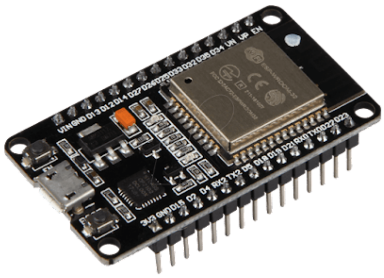

Figure 1: ESP32.

2.2 Soil Moisture Sensor

Soil moisture sensor measures the volumetric content of water inside the soil and gives us the moisture level as output. The sensor is equipped with both analog and digital output. The soil moisture sensor consists of two probes which are used to measure the volumetric content of water. The two probes allow the current to pass through the soil and then it gets the resistance value to measure the moisture value.

When there is more water, the soil will conduct more electricity which means that there will be less resistance. Therefore, the moisture level will be higher. Dry soil conducts electricity poorly, so when there will be less water, then the soil will conduct less electricity which means that there will be more resistance. Therefore, the moisture level will be lower. The soil moisture sensor has four pins : VCC (power), A0 (analog output), D0 (digital output), GND (ground).

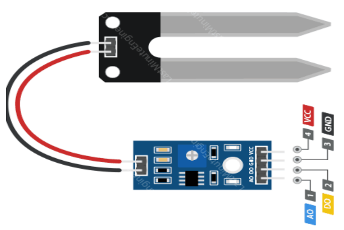

Figure 2: Soil Moisture Sensor.

2.3 DS3231 RTC Module

The DS3231 is an integrated temperature-compensated crystal oscillator (TCXO) and crystal-based low-cost I2C real-time clock (RTC). When the gadget's main power supply is interrupted, the device has a battery input and continues to retain precise time.

The RTC maintains seconds, minutes, hours, day, date, month, and year information. The date at the end of the month is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with an active-low AM/PM indicator. Two programmable time-of-day alarms and a programmable square-wave output are provided.

A precision temperature-compensated voltage reference and comparator circuit monitor the status of VCC to detect power failures, to provide a reset output, and to automatically switch to the backup supply when necessary.

Figure 3: DS3231 RTC Module.

2.4 Thingsboard

An open-source Internet of Things platform called ThingsBoard is used for data collecting, processing, visualization, and device management. It offers a ready-to-use on-premises or cloud IoT solution to enable server-side infrastructure for various IoT applications (Aghenta LO and Iqbal MT, 2019).

ThingsBoard provides 100 percent support for standard IoT protocols for device connectivity, including MQTT, CoAP, and HTTP(S), and it presently supports three different database options: SQL, NoSQL, and Hybrid databases. The ThingsBoard platform uses these databases to store entities (such as devices, assets, dashboards, users, alarms, customers, etc.), and telemetry data (attributes, time-series sensor readings, statistics, events, etc.) (Ismail AA, Hamza HS and Kotb AM,2018).

ThingsBoard has two different editions, the Community Edition, which is free and wholly open source, and the Professional Edition, which has more advanced features. In this research, the Community Edition is used. This Community Edition is open source, and is available free-of-charge on both the ThingsBoard official website and on GitHub software development platform (Aghenta LO and Iqbal MT,2019). The architecture of thingsboard is shown below.

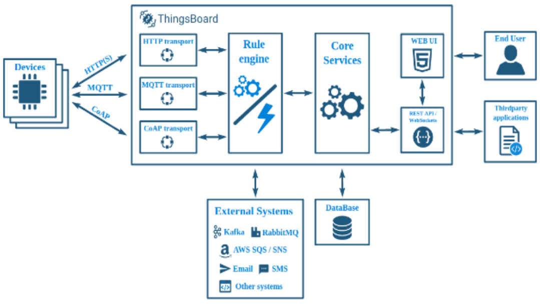

Figure 4: Thingsboard Architecture.

3 RESEARCH METHODOLOGY

3.1 Working Principle for Device

The timing of the application of the potato sprinkler must be determined according to the environment in which it will be employed. To detect if the system or equipment is at watering time or not, a real time clock (RTC) sensor will read the local time. In the morning at 6 am to 8 am and afternoon at 5 pm to 6 pm are the times in question for watering. The soil moisture sensor will read the soil moisture value with a value range of 0 to 1033 if the system is at the time of watering.

If the soil is dry, the system will check the water reservoir to see if there is any water there. If there is enough water there, the system will open the pump to send water to the sprinkler, which will spray water into a designated area.. The following diagram depicts the process flowchart for this system.

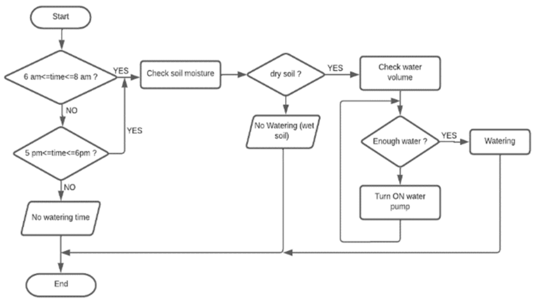

Figure 5: Flowchart system.

Finally, through the IoT platform (thingsboard)., modifications in the status of the system's equipment will be seen.

3.2 Block Diagram

The following block diagram shows how the parts of the IoT platform-based potato sprinkler are related to one another.

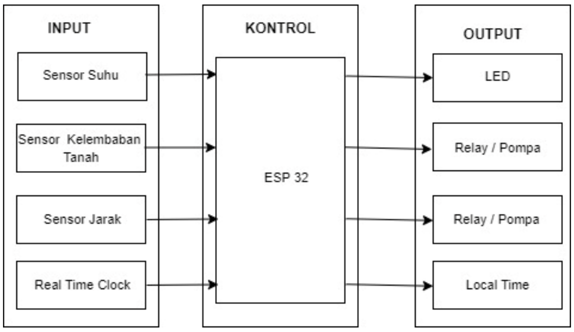

Figure 6: Block Diagram.

This tools three primary parts are input components, control components, and output components, as shown in the image above. The sensor equipment that accepts physical quantities and transforms them into electrical signals makes up the input component. The sensors employed include soil moisture sensors, temperature and humidity sensors (DHT11), ultrasonic sensors, and real-time clock sensors. An ESP32 microcontroller, which has been fitted with a WIFI module, is being used as the control component. It will produce output in the form of ON-OFF watering pump, ON-OFF water tank filling pump, water level in the tank, and information on the state of the soil moisture. Utilizing the IoT platform, specifically thingsboard, the status of the output components and the data they provide are viewed.

3.3 Hardware Design

The following image depicts the hardware design of the tool that was constructed.

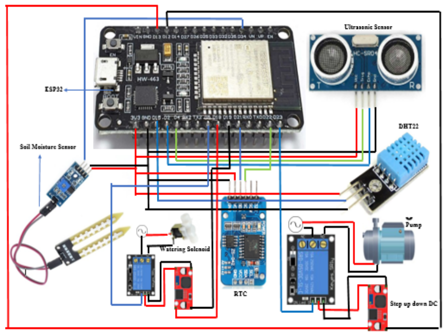

Figure 7: Hardware Design.

The analysis of the needs for this sprinkler component is as shown in the following table:

Table 1: Kebutuhan hardware.

Component	Specification	Function
ESP32	• Dual-core Tensilica LX6 microprocessor • 520 kB internal SRAM • Integrated 802.11 BGN WiFi transceiver • 2.2 to 3.6V operating range, 32 GPIO	Board controller
Soil Moisture YL69	• Operating Voltage: 3.3V to 5V DC • Operating Current: 15mA • Output Digital/ Analog - 0V to 5V	Soil moisture sensor
DHT11	• Operating voltage: 3.5V hingga 5.5V • Operating current: 0.3mA • Output: serial data, • Temperature range : -40 ° C hingga 80 ° C • Moisture range: 0% hingga 100%	Read temperature and air moisture
Relay 2 channel	• Operating voltage : 5V DC • Operating current : -+40mA (20mA/channel) • Trigger voltage : Low Level Setting : 0~1.5V DC High Level Setting : 3~5V DC • Arus trigger : 2~5mA Kontak Beban : NO dan NC Max 250V AC 10A atau 30V DC 10A Dimensi : 50 x 41 x 17.5 mm	Electric switch for pump and sprinkler
RTC DS3231	• Operating voltage : 2.3V – 5.5V • Operating current 500nA • Maximum voltage on SDA , SCL : VCC + 0.3V • Operating temperature : -45ºC to +80ºC	Updating date and time periodically
Ultrasonic HC-SR04	• Voltage : 5V DC • Static current : < 2mA • Output level : 5v – 0V • Sensor angle : < 15 derajat • Detectable distance: 2cm – 450cm (4.5m) • Acuracy : up to 0.3cm (3mm)	To measure distance

4 RESULT

4.1 Determination of Soil Moisture Limits for Watering

The soil moisture limit is a parameter used to determine when a HIGH or LOW signal is sent to the watering pump relay. The results of soil moisture testing done in potato plant pots under various weather and air temperature conditions are displayed in the following table:

Table 2: Soil moisture under various soil conditions.

Condition of potato plants in pots	Air temperature	Moisture value
Plants are not watered for 2 days	31^{0}C	907
Plants are not watered for 2 days	28^{0}C	829
It rained last night	28^{0}C	735
It rained an hour ago	31^{0}C	356
The plants have been hit by the rain	31^{0}C	294

The soil moisture limit is established at a value of 670 based on the data in the table above and a visual inspection of the condition of the soil.

4.2 Pengujian Fungsionalitas Simulasi Dan Prototype

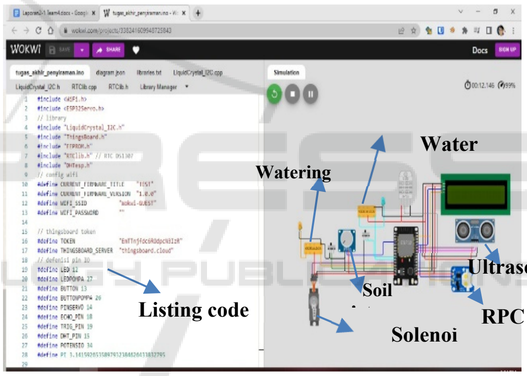

Figure 8: System Simulation.

The simulation of potato sprinklers was made using a wokwi software which is software for simulating embedded systems and IoT (Figure 8). The prototype model is as shown in Figure 9.

Figure 9: Sistem Prototype.

In the simulation above, the soil moisture sensor is represented by a potentiometer because the Wokwi software does not provide this sensor feature. Solenoid describes a watering device controlled by a relay. The following scenarios were created to test the feature, and the outcomes of each scenario were shown graphically on the thingsboard:

- Scenario 1; soil moisture 502 (soil wet due to rain) air temperature 300C. The potato plants are not being watered in this situation.

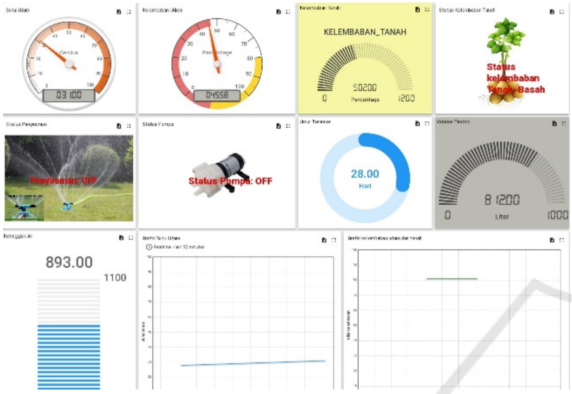

Figure 10: Scenario 1.

- Scenario 2; soil moisture 802 (dry soil) air temperature 30^{0}C. In this condition, watering occurs because the water in the water tank is still sufficient (>250L).

Figure 11: Scenario 2.

- Scenario 3; soil moisture 802 (dry soil) air temperature 30^{0}C. There is no watering and the water pump is ON because there is only about 250L of water in the tank.

Figure 12: Scenario 3.

The three scenarios can be run and visualized on the thingsboard platform so well that it can be said that this system has worked as planned.

5 CONCLUSIONS

Based on the scenario created, the autonomous potato sprinkler has been put through testing. The findings demonstrate that the device performs as planned. The test results are shown using the IoT platform (thingsboard) and show the current state of all used devices. This device is highly helpful since it can reduce the need for labor while correctly monitoring water use.

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