IOT-BASED SMART FARMING SYSTEM

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Software Engineering for The Internet of Things

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Contents

1. Introduction

The **IoT-Based Smart Farming System** is designed to monitor environmental conditions in agricultural fields using IoT sensors. It collects real-time data on **temperature, humidity, soil moisture, and light intensity**, processes it via **MQTT**, stores it in **InfluxDB**, and visualizes it in **Grafana**. Alerts are sent via **Node-RED to Telegram** when values exceed predefined thresholds.

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2. Objectives

2.1. Real-Time Environmental Monitoring

- Continuously track **temperature, humidity, soil moisture, and light intensity** across multiple farms.

2.2. Intelligent Alert System

- Notify farmers when conditions exceed safe thresholds to take immediate action.

2.3. Data Visualization

- Provide a **user-friendly Grafana dashboard** with real-time sensor graphs.

2.4. Scalable & Automated Solution

- Support multiple farms with **structured MQTT topics** and **automated data collection**.

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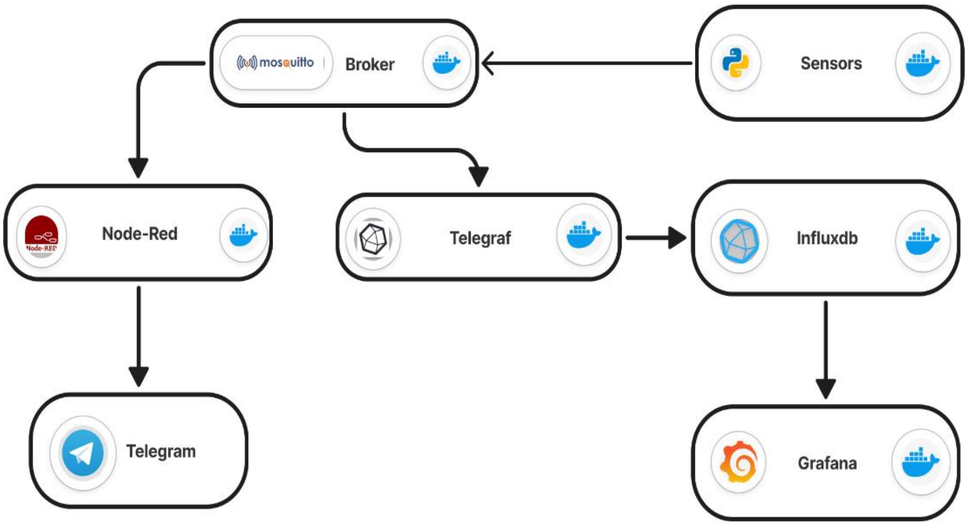
3. System Architecture & Data Flow

3.1. System Components

1. **MQTT Broker (Mosquitto)** - Manages sensor data exchange between publishers and subscribers.
2. **Sensor Nodes (Python MQTT Publisher)** - Simulated sensors that publish environmental data via MQTT.
3. **Telegraf** - A lightweight agent that subscribes to MQTT topics and forwards data to InfluxDB.
4. **InfluxDB** - A time-series database used to store sensor readings for efficient querying.
5. **Grafana** - A visualization tool that displays real-time sensor data in customizable dashboards.
6. **Node-RED** - A flow-based tool for handling IoT data processing and triggering alerts.
7. **Telegram Bot** - A messaging service that sends notifications for abnormal sensor conditions.

3.2. Data Flow



1. **Sensor Nodes publish data** → MQTT Broker (**Mosquitto**)
2. **Telegraf subscribes to MQTT topics** → Stores data in **InfluxDB**
3. **Grafana queries InfluxDB** → Displays data visually
4. **Node-RED listens to MQTT** → Sends alerts if thresholds are exceeded
5. **Alerts are sent to Telegram** in case of critical conditions

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4. Functional and Non-Functional Requirements

4.1. Functional Requirements (FRs)

1. **Real-Time Data Collection** - The system must collect and transmit sensor data in real-time.
2. **MQTT Communication** - Data exchange between sensors and the system must use MQTT.
3. **Data Storage in InfluxDB** - The system must store sensor readings in InfluxDB for historical analysis.
4. **Dashboard Visualization** - The system must provide a real-time dashboard using Grafana.
5. **Alerting Mechanism** - The system must send alerts when sensor values exceed thresholds.
6. **Multiple Farm Support** - The system must handle and differentiate data from multiple farms.

4.2. Non-Functional Requirements (NFRs)

1. **Scalability** - The system must support additional sensors and farms without performance degradation.
2. **Reliability** - The system must ensure continuous operation with minimal downtime.
3. **Security** - Data transmitted over MQTT must be secured to prevent unauthorized access.
4. **Performance** - The system should process and store data efficiently to prevent delays.
5. **Usability** - The dashboard and alert system should be user-friendly and easy to configure.

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5. Structured MQTT Topic Naming Convention

To ensure scalability, MQTT topics follow a structured naming convention:

```
farming/farm_X/sensor_type
```

Example Topics

```
farming/farm_1/temperature
farming/farm_2/humidity
farming/farm_1/soil_moisture
farming/farm_2/light_intensity
```

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6. Sensor Data Publisher (Python MQTT Client)

6.1. Key Features

- Generates **simulated** temperature, humidity, soil moisture, and light intensity data.
- Uses **multithreading** to simulate multiple farms.
- Publishes data in **JSON format** to structured MQTT topics.
- **Reconnects automatically** if MQTT broker is unavailable.

6.2. Sample MQTT Data Payload

```
{
    "temperature": 30.5,
    "farm": "farm_1"
}
```

6.3. Configuration File (`config.ini`)

```
[data_generation]
farms = 2
time_sleep = 5
sensors = temperature|humidity|soil_moisture|light_intensity
```

---

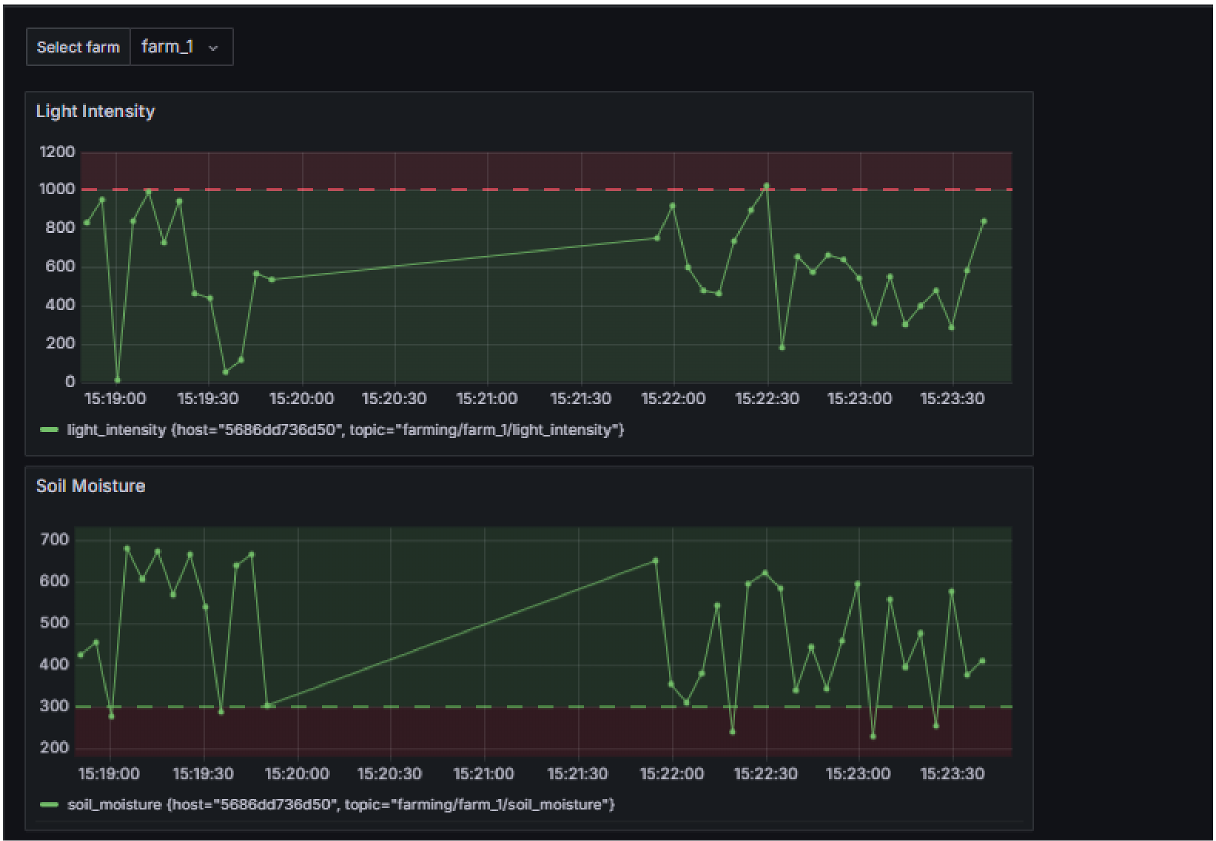
7. Storing Data in InfluxDB using Telegraf

7.1. Telegraf Configuration (`telegraf.conf`)

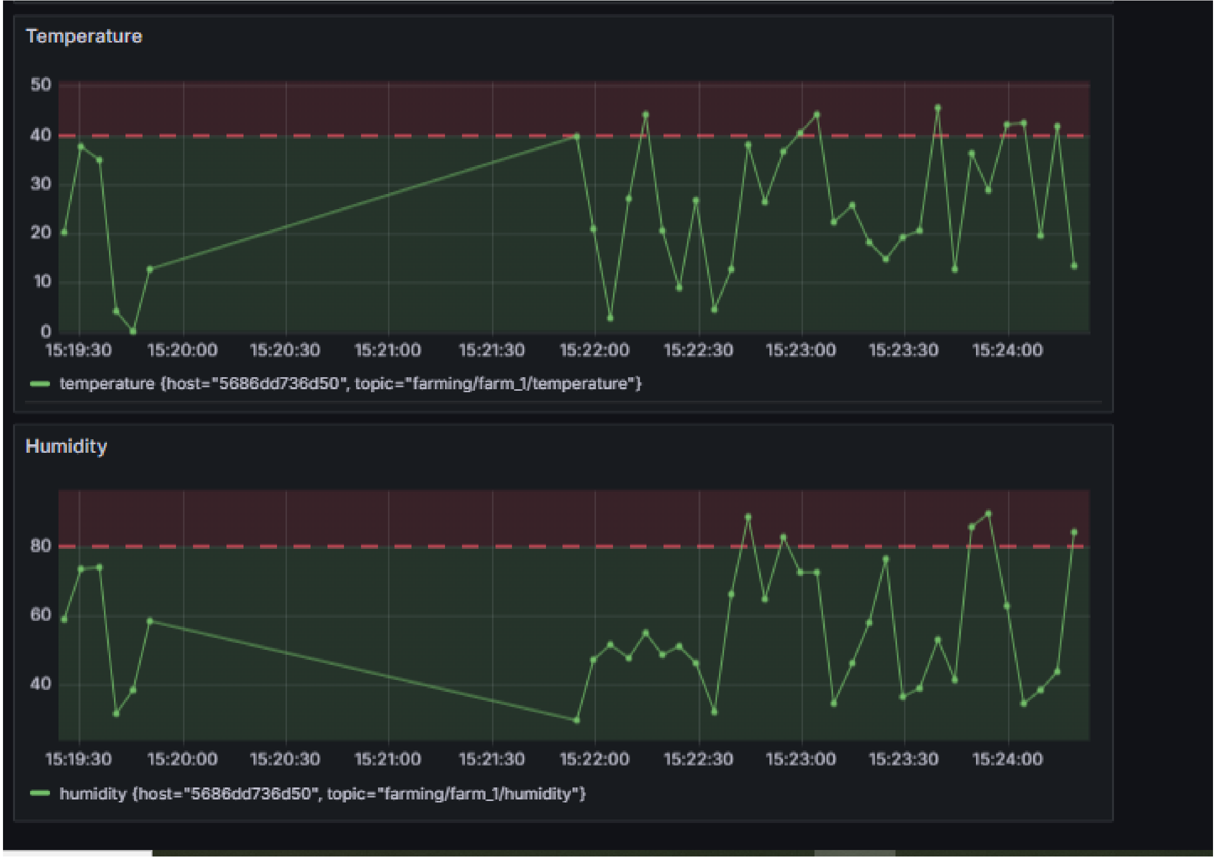
```
[[inputs.mqtt_consumer]]
  servers = ["tcp://mosquitto:1883"]
  topics = ["farming/+/+"]
  data_format = "json"

[[outputs.influxdb_v2]]
  urls = ["http://influxdb:8086"]
  token = "my-secret-token"
  organization = "my_org"
bucket = "farming"
```

8. Explanation of Grafana Results

- You should see a **dropdown** in Grafana (e.g., "farm_1", "farm_2").
- When you select a farm, **all panels should update** to show data for that specific farm.
- This is done using **Grafana variables** (e.g., `$farm` for dynamic filtering).



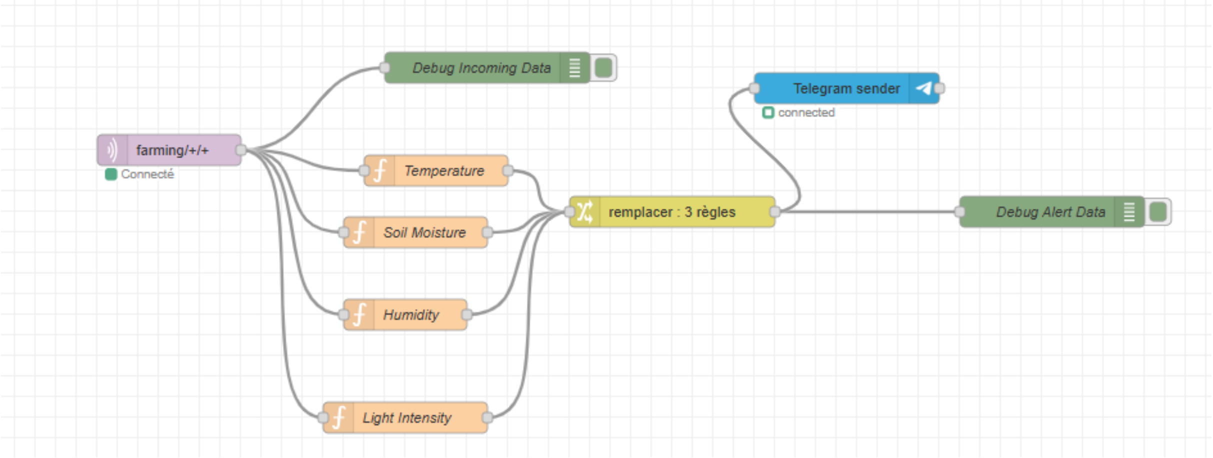
Select farm
farm_1
Light Intensity
1200
1000
800
600
400
200
0
15:19:00
15:19:30
15:20:00
15:20:30
15:21:00
15:21:30
15:22:00
15:22:30
15:23:00
15:23:30
light_intensity {host="5686dd736d50", topic="farming/farm_1/light_intensity"}
Soil Moisture
700
600
500
400
300
200
15:19:00
15:19:30
15:20:00
15:20:30
15:21:00
15:21:30
15:22:00
15:22:30
15:23:00
15:23:30
soil_moisture {host="5686dd736d50", topic="farming/farm_1/soil_moisture"}



Temperature
50
40
30
20
10
0
15:19:30
15:20:00
15:20:30
15:21:00
15:21:30
15:22:00
15:22:30
15:23:00
15:23:30
15:24:00
temperature {host="5686dd736d50", topic="farming/farm_1/temperature"}
Humidity
80
60
40
15:19:30
15:20:00
15:20:30
15:21:00
15:21:30
15:22:00
15:22:30
15:23:00
15:23:30
15:24:00
humidity {host="5686dd736d50", topic="farming/farm_1/humidity"}

9. Node-Red and Telegram:

I employed Node-RED, an IoT visual programming tool, to analyze data retrieved from MQTT Broker. This analysis was used to trigger alerts via a Telegram bot when the system detected some values that are not normal. From the Telegram side, I used “BotFather”, which is a bot created by Telegram that allows you to create and manage your own bots.



Create the Telegram Bot

a. Create/open a telegram account

b. Search for @botfather in the Telegram search bar

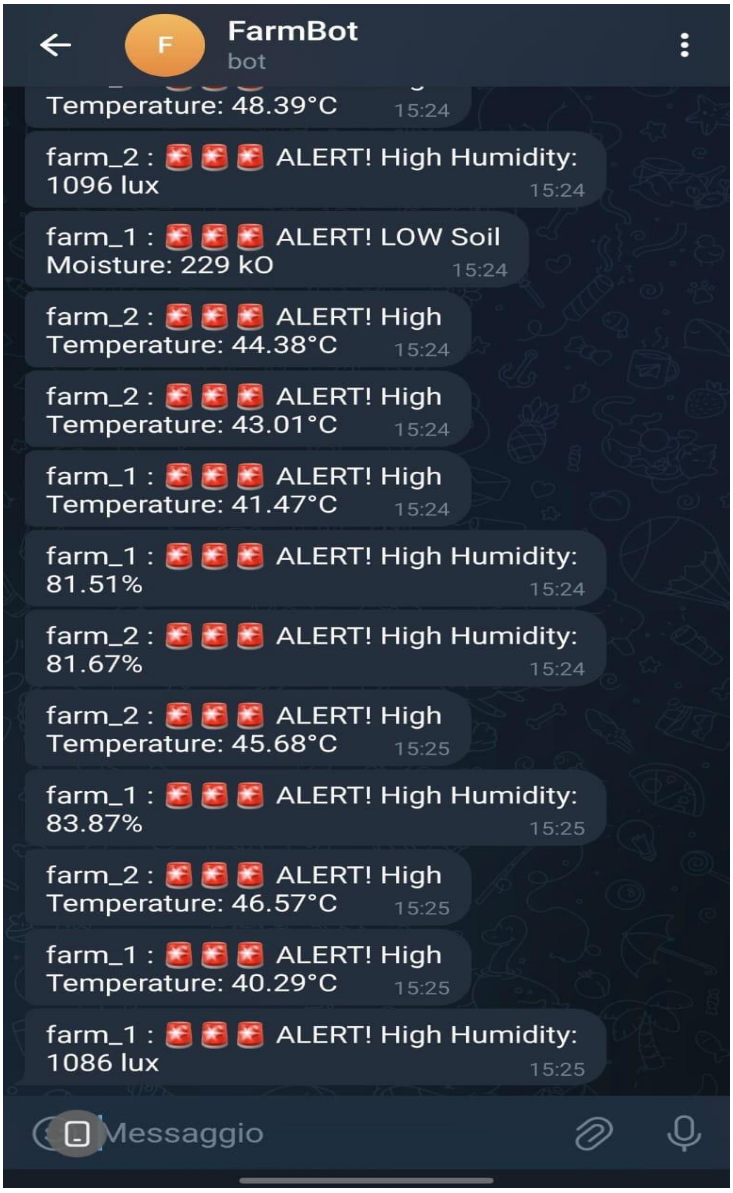
c. Click on the Start button to interact with the BotFather

d. Type /newbot, and follow the prompts to set up a new bot.

e. Save the token the BotFather provides. You will use it to authenticate to the Telegram API and interact with your bot.

f. In your newly created bot, send the message /start to activate the bot.

In the bot the messages will arrive like this:



Temperature: 48.39°C 15:24

farm_2 : 🚨🚨🚨 ALERT! High Humidity: 1096 lux 15:24

farm_1 : 🚨🚨🚨 ALERT! LOW Soil Moisture: 229 kO 15:24

farm_2 : 🚨🚨🚨 ALERT! High Temperature: 44.38°C 15:24

farm_2 : 🚨🚨🚨 ALERT! High Temperature: 43.01°C 15:24

farm_1 : 🚨🚨🚨 ALERT! High Temperature: 41.47°C 15:24

farm_1 : 🚨🚨🚨 ALERT! High Humidity: 81.51% 15:24

farm_2 : 🚨🚨🚨 ALERT! High Humidity: 81.67% 15:24

farm_2 : 🚨🚨🚨 ALERT! High Temperature: 45.68°C 15:25

farm_1 : 🚨🚨🚨 ALERT! High Humidity: 83.87% 15:25

farm_2 : 🚨🚨🚨 ALERT! High Temperature: 46.57°C 15:25

farm_1 : 🚨🚨🚨 ALERT! High Temperature: 40.29°C 15:25

farm_1 : 🚨🚨🚨 ALERT! High Humidity: 1086 lux 15:25

10. Conclusion

This **IoT Smart Farming System** successfully integrates **real-time monitoring, data storage, visualization, and alerts**. Future improvements include:

- **AI-based anomaly detection**.
- **Integration with weather APIs** for predictive insights.
- **Mobile App for real-time alerts & control**.