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Smart Automation Driven Urban Farming Setup

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Abstract - *The World Bank estimates around 34% of India's population live in urban environments and the number have been drastically increasing. This leads to profound problems and one of the primary problems is the obvious disparity in the market, the high demands of the growing urban population and the primary agrarian sector struggling to provide quality produce to meet the needs. This is the context where urban farming comes in, it the practice of growing your own crops for consumption. The most viable method is hydroponics. But even though these systems and ideas have been around for decades, it is far from solving any problems at scale and this is where we think technology can make an impact. The problem with traditional hydroponics are it is a highly monitored process and hence if done manually, it requires lots of labour force, for every to grow, a feedback cycle that depicts the current "state" of the plant and/or its health is vital for large adoption. It is time consuming and it does not make business sense for people to grow a crop for 6 month or that they can consume it over one meal. Plant diseases are not easily diagnosed and pesticides degrade the quality of the food and total lack of automation and scalability in design of conventional hydroponic farms.*

***Key Words*: Hydroponics, IoT, Smart Automation, Urban Farming**

1. INTRODUCTION

Hydroponic is a method of growing plants using mineral nutrient solutions in water, without soil It produces higher yields than the traditional soil-based agriculture. Hydroponic plants have a higher pest resistance which eliminates the higher use of pesticides. The future of agriculture seems to be decentralized and would involve a lot of micro farms. The scope for micro farms will be the only sustainable way to cater to the food produce requirement. A simple, efficient and a reliable system is all that is needed to make this a reality.

1.1 Objectives

In this paper we propose a system that is built with the following objectives in mind:

1. To build a reliable and simple to use automation system.
2. An efficient sensor network for data collection.
3. An automation system which adapts to the given requirement.
4. Modular system components
5. ML model for detection of plant diseases
6. Have a seamless sensor and gateway integration.
7. Based on the received data having Real Time Analytics
8. Remote maintenance as well as having an OTA update feature.
9. Increase the growth rate

1.2 Expected Results

Some of the other results expected are a highly scalable system with modular design and remote maintenance and with features such as real time data and environmental optimum auto - configuration while making sure all components are sourced hyper locally.

2. Proposed Solution

We use IoT driven technology to setup a system that helps us achieve the above results.

2.1 Top level view

In our setup, every sensor unit in the farm collects data points of the environment and sends it to an esp32 gateway. This process can be done in a variety of ways and various network architectures and mediums can be experimented with. The most common ones are mesh architecture over BLE or WIFI. We used ESPRESSIF 'S mesh network framework to build a network that features an automatically connecting mesh, up to 10 Mbps data transfer rate, every node acting as a router and up to 200 meters for a hop between two nodes.

Now that the data is collected through on-the -ground sensor units, it is relayed to a central node or local gateway. This local gateway then pushes the data to the central remote cloud interface in a structured JSON format. There are plenty of protocols that facilitate low latency and highly frequent data transfer built for IoT solutions. The primary market leader being MQTT. MQTT is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol. It was designed as an extremely lightweight publish/subscribe messaging transport. It is useful for connections with remote locations where a small code footprint is required and/or network bandwidth is at a premium. It is also ideal for mobile applications because of its small size, low power usage, minimized data packets, and efficient distribution of information to one or many receivers. Considering the mentioned and also the fact that MQTT is more tested and tried in the industry compared to other protocols, we stuck with it to transfer data from premise-to-cloud.

Once the data reaches the cloud, it is processed and stored in a time series manner. The data is initially checked for format specifications and other parameters. It is then sent to a data warehouse facility where it is then stored for further analysis. The storage is built on the big-query platform. This enables auto scaling and reliable storage mechanisms. The data is then mined to analyze data patterns and other anomalies that could add pointers to the growth metrics of the plants in the farm in consideration.

Remote control of the farm is a vital element of the setup in consideration. This can be implemented in various ways. The two most prominent market options are MQTT channels based and RPC over HTTP based. We used both of the mentioned in the setup. MQTT was used to facilitate message delivery commitment with its various QS levels. It was used to aid the necessary and important configuration changes that can be applied remotely. RPC over HTTP being extremely lightweight but without message guarantee was used to facilitate immediate remote commands that do not require guarantees.

Controls and data inference need a user interface for consumption and control signals. In our system the user can either communicate through the app or a web dashboard. These interfaces are used by the user to read analyzed reports on the farm setup which include health status of the crops, levels of water and current appliances in use in the farm etc. This interface also facilitates the submissions of commands that include all appliance controls and changing scheduled timers remotely.

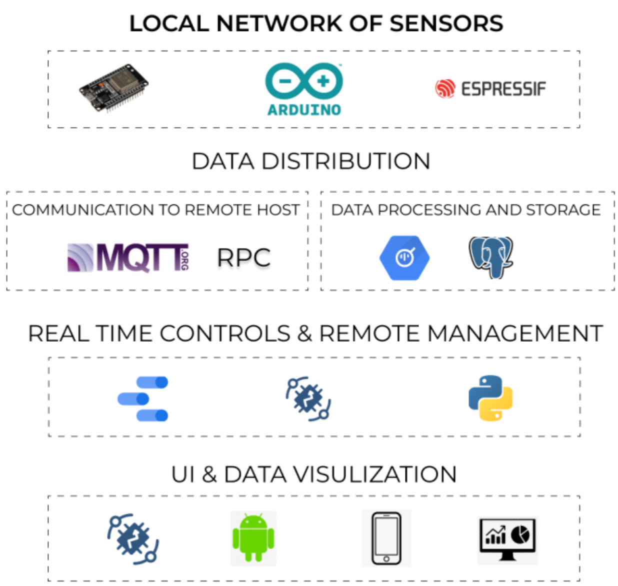

Fig -1: Top Level Diagram

2.2 Use case analysis

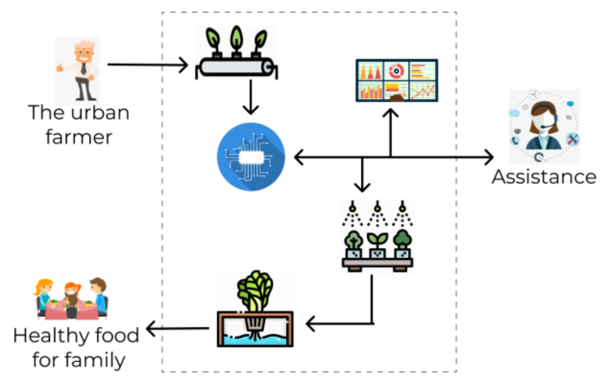

Fig -2: Use Case Diagram

2.3 Data Flow analysis

A feature-rich MCU with integrated Wi-Fi and Bluetooth connectivity for a wide-range of applications.ESP32 is capable of functioning reliably in industrial environments, with an operating temperature ranging from –40°C to +125°C. Powered by advanced calibration circuitries, ESP32 can dynamically remove external circuit imperfections and adapt to changes in external conditions. Engineered for mobile devices, wearable electronics and IoT applications, ESP32 achieves ultra-low power consumption with a combination of several types of proprietary software. ESP32 also includes state-of-the-art features, such as fine-grained clock gating, various power modes and dynamic power scaling. ESP32 is highly-integrated with in-built antenna switches, RF, power amplifier, low-noise receive amplifier, filters, and power management modules. ESP32 adds priceless functionality and versatility to your applications with minimal Printed Circuit Board (PCB) requirements. SP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor. ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI / SDIO or I2C / UART interfaces.

Our gateway is a physical device or software program that serves as the connection point between the cloud and controllers, sensors and intelligent devices. All data moving to the cloud, or vice versa, goes through the gateway, which can be either a dedicated hardware appliance or software program. Another benefit of an IoT gateway is that it can provide additional security for the IoT network and the data it transports. Because the gateway manages information moving in both directions, it can protect data moving to the cloud from leaks and IoT devices from being compromised by malicious outside attacks with features such as tamper detection, encryption, hardware random number generators and crypto engines

An MQTT client can publish messages as soon as it connects to a broker. MQTT utilizes topic-based filtering of the messages on the broker (see part 2 for details). Each message must contain a topic that the broker can use to forward the message to interested clients. Typically, each message has a payload which contains the data to transmit in byte format. MQTT is data-agnostic. The use case of the client determines how the payload is structured. The sending client (publisher) decides whether it wants to send binary data, text data, or even full-fledged XML or JSON.

Publishing a message doesn't make sense if no one ever receives it. In other words, if there are no clients to subscribe to the topics of the messages. To receive messages on topics of interest, the client sends a SUBSCRIBE message to the MQTT broker. This subscribe message is very simple, it contains a unique packet identifier and a list of subscriptions. Packet Identifier The packet identifier uniquely identifies a message as it flows between the client and broker. The client library and/or the broker is responsible for setting this internal MQTT identifier.

List of Subscriptions A SUBSCRIBE message can contain multiple subscriptions for a client. Each subscription is made up of a topic and a QoS level. The topic in the subscribe message can contain wildcards that make it possible to subscribe to a topic pattern rather than a specific topic. If there are overlapping subscriptions for one client, the broker delivers the message that has the highest QoS level for that topic.

Data Warehousing (DW) is a process for collecting and managing data from varied sources to provide meaningful business insights. A Data warehouse is typically used to connect and analyze business data from heterogeneous sources. The data warehouse is the core of the BI system which is built for data analysis and reporting.

It is a blend of technologies and components which aids the strategic use of data. It is electronic storage of a large amount of information by a business which is designed for query and analysis instead of transaction processing. It is a process of transforming data into information and making it available to users in a timely manner to make a difference.

Data is useless without meaning. The web dashboard and mobile application intend to convey meaning full data and insightful information at the right time for the user. Control is critical to any technological intervention. All devices and sensor units in the ground(farm) can be controlled remotely using the dashboard or app.

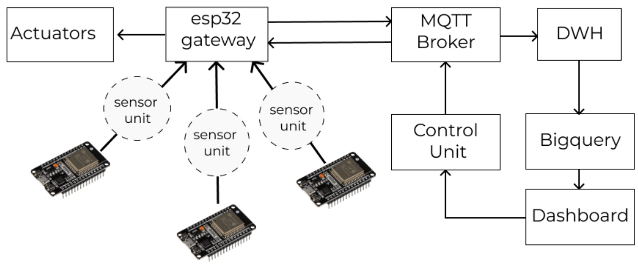

Fig -3: Data Flow Diagram

3. CONCLUSIONS

We mentioned the need for a completely automated infrastructure for hydroponics urban farms in the initial abstract. Through this report we proposed our efforts to build a system that not only solves the current market problems but also solves it keeping user simplicity and system reliability at the forefront. This will help people to set up an urban farm in their houses or neighbourhoods in a cost efficient and productive manner.

The use of state-of-the-art technology in the process defines this as a system that relies on international standards and protocols. We intend to use this base to bootstrap for scale and build an ecosystem that provides valuable and informative feedback to growers and also a method in which the harvest of the crops can be sold to nearby growers through a business model.

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