Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 44 No. 6
June 2023

Microsoft Cloud Plug-N-Play IoT Solution for Hydroponic Protected Cultivation

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Abstract

Introduction: Introducing Microsoft Cloud Plug-N-Play IoT Solution for Hydroponic Protected Cultivation—a cutting-edge technology designed to revolutionize the way we grow plants in controlled environments. This comprehensive solution combines the power of Microsoft Azure's cloud services with the seamless integration of IoT devices, enabling growers to monitor and manage their hydroponic systems with unprecedented ease. With real-time data insights, automated controls, and predictive analytics, this solution empowers farmers to optimize resource utilization, improve crop yields, and enhance sustainability practices. Embrace the future of agriculture with Microsoft Cloud Plug-N-Play IoT Solution for Hydroponic Protected Cultivation.

Objectives: Improve crop yield and quality through optimized environmental control.Streamline resource management by monitoring and optimizing resource utilization.Enable remote monitoring and control of hydroponic systems for increased efficiency and productivity.

Methods: The solution integrates IoT devices such as sensors and actuators to collect real-time data on environmental factors, plant health, and resource consumption.By utilizing Microsoft Azure's cloud services, the solution applies advanced analytics and machine learning algorithms to analyze the collected data and generate actionable insights for optimizing crop cultivation. The solution enables automated control of environmental parameters, nutrient delivery systems, and irrigation schedules based on predefined thresholds and algorithms, ensuring optimal conditions for plant growth. Through cloud connectivity, growers can remotely monitor and manage their hydroponic systems, accessing real-time data, receiving alerts, and making adjustments from anywhere, improving operational efficiency and responsiveness.

Results: The optimized environmental control and resource management provided by the solution contribute to increased crop yields and enhanced productivity misadjusting, growers can achieve significant reductions in water, energy, and fertilizer consumption, leading to improved sustainability and cost savings. The ability to remotely monitor and manage hydroponic systems through the cloud-based solution enables growers to efficiently oversee multiple cultivation sites, make timely adjustments, and troubleshoot issues without being physically present. The solution's data analytics capabilities provide growers with valuable insights into crop performance, enabling informed decision-making, proactive problem-solving, and continuous improvement in hydroponic farming practices.

Conclusions: In conclusion, the Microsoft Cloud Plug-N-Play IoT Solution for Hydroponic Protected Cultivation offers a transformative approach to hydroponic farming. With optimized environmental control, resource management, and remote accessibility, growers can achieve higher crop yields, improved resource efficiency, and data-driven decision making, propelling the future of sustainable and productive agriculture.

Keywords: Microsoft, Cloud Plug-N-Play, IoT Solution, Hydroponic, Protected Cultivation, crop yield, resource management, remote monitoring, environmental control, data analytics, sustainability.

1. Introduction

Hydroponic protected cultivation, also known as greenhouse farming, is a rapidly growing method of agriculture that allows for efficient and controlled plant growth in a protected environment. It offers numerous advantages over traditional soil-based farming, including higher yields, reduced water consumption, and optimal resource management. To further enhance the productivity and sustainability of hydroponic farming, the integration of Internet of Things (IoT) technologies has become increasingly popular.

Microsoft, a leading technology company, has developed the Cloud Plug-N-Play IoT Solution specifically tailored for hydroponic protected cultivation. This innovative solution combines Microsoft's expertise in cloud computing, IoT connectivity, and data analytics to create a comprehensive platform that empowers farmers to monitor and manage their hydroponic systems more effectively.

The Microsoft Cloud Plug-N-Play IoT Solution offers a seamless integration of hardware devices, software applications, and cloud services, simplifying the deployment and management of IoT solutions for hydroponic farming. With this solution, farmers can easily connect various IoT devices, such as sensors, controllers, and actuators, to their greenhouse infrastructure. These devices capture real-time data on crucial parameters like temperature, humidity, light levels, nutrient concentrations, and water quality.

The collected data is then transmitted to the cloud, where it is processed and analyzed using advanced analytics tools and machine learning algorithms. This enables farmers to gain valuable insights into the performance of their hydroponic systems, identify trends, detect anomalies, and make data-driven decisions to optimize crop production. Moreover, the solution provides intuitive dashboards and visualizations, enabling farmers to monitor their greenhouse conditions remotely and take necessary actions promptly.

One of the significant advantages of the Microsoft Cloud Plug-N-Play IoT Solution is its scalability and flexibility. It supports a wide range of IoT devices and protocols, allowing farmers to choose the hardware that best suits their specific needs. Additionally, the solution seamlessly integrates with Microsoft Azure, a powerful cloud computing platform, providing farmers with access to a vast ecosystem of services for data storage, processing, and application development.

By leveraging the Microsoft Cloud Plug-N-Play IoT Solution, hydroponic farmers can unlock new levels of productivity, efficiency, and sustainability in their operations. They can optimize resource allocation, prevent crop diseases, automate irrigation and nutrient delivery, and ensure optimal growing conditions for their plants. Ultimately, this leads to higher crop yields, improved crop quality, reduced costs, and minimized environmental impact.

2. Objectives

The objective of monitoring humidity, temperature, and total dissolved solids (TDS) in hydroponic cultivation is to ensure optimal growing conditions for plants and enable proactive management of the hydroponic system. By continuously monitoring these parameters, farmers can gain valuable insights into the environmental factors that directly impact plant growth and make data-driven decisions to maximize crop productivity and quality. The specific objectives of monitoring humidity, temperature, and TDS are as follows:

Optimize Growing Environment: By monitoring humidity and temperature levels within the hydroponic environment, farmers can ensure that the conditions are optimal for plant growth. Humidity affects transpiration rates, nutrient uptake, and disease susceptibility, while temperature impacts metabolic processes and overall plant health. By maintaining the ideal range for these parameters, farmers can create a favourable environment that promotes healthy growth and minimizes the risk of stress or diseases.

Prevent Crop Loss: Fluctuations in humidity and temperature can lead to adverse effects on plant health, such as Mold growth, wilting, or heat stress. By monitoring these parameters, farmers can promptly identify and address unfavourable conditions before they cause significant damage to the crops. Early detection of abnormal humidity and temperature levels allows for timely adjustments to ventilation, heating, or cooling systems, thus preventing crop loss and ensuring higher yields.

Optimize Nutrient Delivery: Total Dissolved Solids (TDS) refers to the concentration of dissolved nutrients in the hydroponic solution. Monitoring TDS levels provides insights into the nutrient availability for plants and enables farmers to adjust nutrient dosages accordingly. By maintaining appropriate TDS levels, farmers can ensure that plants receive the right balance of essential nutrients, promoting healthy growth and preventing nutrient deficiencies or toxicities.

Data-Driven Decision-Making: Continuous monitoring of humidity, temperature, and TDS generates a wealth of data that can be analyzed to identify patterns, trends, and correlations. By leveraging data analytics and machine learning algorithms, farmers can gain deeper insights into the relationships between these parameters and crop performance. This knowledge can inform decision-making processes, such as adjusting environmental control settings, modifying nutrient formulations, or implementing preventive measures, to optimize crop production and quality.

Automation and Remote Monitoring: Integrating IoT devices and cloud-based solutions enables automation and remote monitoring of humidity, temperature, and TDS levels. Farmers can receive real-time alerts and notifications when the monitored parameters deviate from the desired ranges, allowing them to take immediate action, even when they are not physically present at the greenhouse. This capability enhances operational efficiency, saves time, and enables proactive management of the hydroponic system.

3. Methods

As shown in the below figure proposed architecture include three layers data ingestion, processing & analytics and presentation.

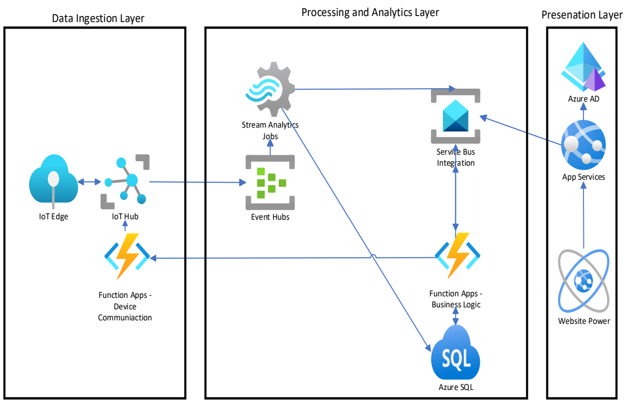

Fig 1 . Actual Architecture

1. Data Ingestion Layer:

The data ingestion layer is responsible for collecting data from IoT devices and sending it to the cloud for further processing and analysis. In this architecture, the data ingestion layer consists of the following components:

IoT Edge: IoT Edge is a platform that runs on edge devices and allows for local data processing and filtering before sending it to the cloud. It enables edge intelligence and reduces the amount of data transmitted to the cloud, optimizing bandwidth usage.

IoT Hub: IoT Hub acts as a central hub for device-to-cloud and cloud-to-device communication. It securely connects and manages IoT devices, allowing them to send telemetry data to the cloud. In this architecture, IoT Hub receives data from IoT Edge devices.

Function App: Function App is a serverless compute service that enables the execution of code in a serverless environment. In this architecture, the Function App facilitates communication between the IoT Edge devices and IoT Hub. It handles any required data transformations or actions before forwarding the data to IoT Hub.

2. Processing and Analytics Layer:

The processing and analytics layer is responsible for processing and analyzing the data received from the data ingestion layer. It consists of several components that enable data transformation, analysis, and storage. In this architecture, the processing and analytics layer includes the following components:

IoT Hub: As mentioned earlier, IoT Hub plays a dual role in the architecture. After receiving data from IoT Edge devices, IoT Hub serves as a data source for subsequent components in the processing and analytics layer.

Event Hubs: Event Hubs is a highly scalable event streaming platform that allows for real-time data ingestion. In this architecture, Event Hubs receives the data from IoT Hub and acts as an intermediary data buffer before further processing.

Stream Analytics: Stream Analytics is a real-time analytics service that enables the processing and analysis of streaming data. In this architecture, Stream Analytics ingests data from Event Hubs and applies various transformations and analytics operations to derive insights from the data.

Service Bus Integration and Azure SQL: Service Bus Integration allows for the integration of different services and systems. In this architecture, it serves to connect Stream Analytics with Azure SQL. Azure SQL, a managed relational database service, is used for storing the processed and analyzed data.

Function App: Like the data ingestion layer, the Function App in the processing and analytics layer handles communication between Stream Analytics and Azure SQL. It can perform additional data transformations or trigger further actions based on the processed data.

3. Presentation Layer:

The presentation layer focuses on visualizing and presenting the data and insights derived from the processing and analytics layer. In this architecture, the presentation layer includes the following components:

Azure AD and Service Bus: Azure AD (Azure Active Directory) is a cloud-based identity and access management service. It enables secure authentication and authorization for accessing the resources in the presentation layer. Service Bus, as mentioned earlier, facilitates the integration between different services.

App Services: App Services is a platform-as-a-service (PaaS) offering that enables the hosting and deployment of web applications. In this architecture, App Services hosts the website that will serve as the user interface for accessing the data and insights.

Website: The website is the user-facing interface where users can interact with the hydroponic data and visualizations. It is hosted on the App Services platform and can leverage Azure AD for secure authentication and authorization.

Power BI: Power BI is a business analytics tool that provides interactive visualizations and business intelligence capabilities. In this architecture, Power BI can be used to create dashboards and reports based on the processed and analyzed data, offering rich and dynamic visual representations of the hydroponic cultivation insights.

By structuring the architecture into these layers, the hydroponic system can effectively ingest, process, analyze, and presentdata, providing valuable insights for monitoring and managing the hydroponic protected cultivation.

4. Results

In this section schematic diagram, actual hardware and simulation outputs are discuss in briefly.

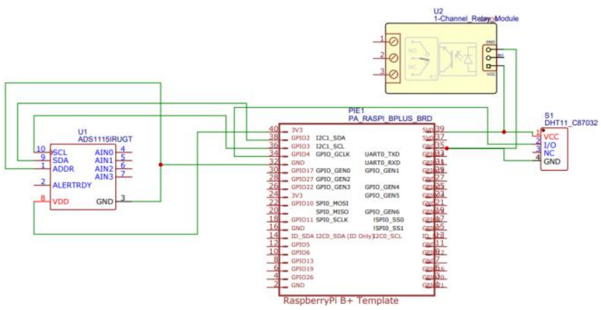

Fig 2. Schematic Diagram

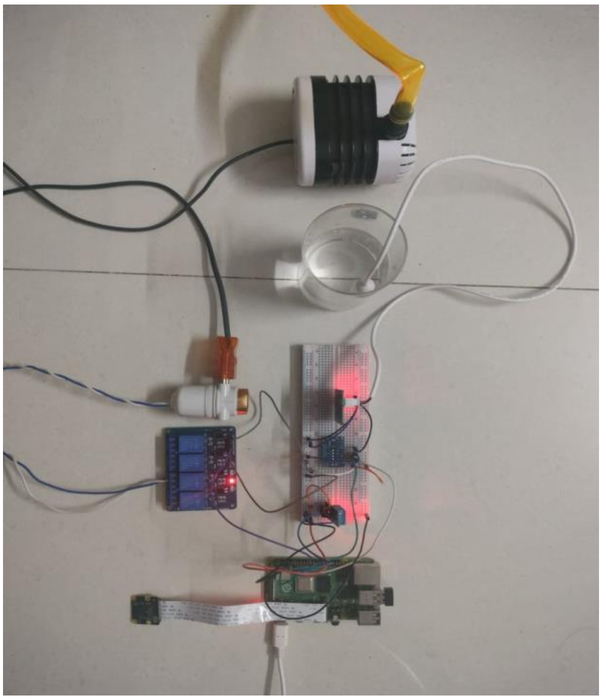

Fig 3. Actual Hardware

Fig 4. Main Page

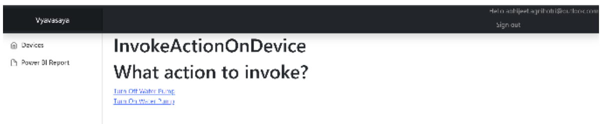

Fig 5. Invoke Action

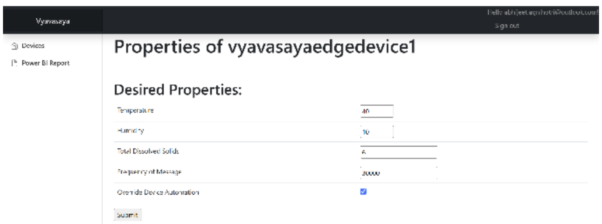

Fig 6. Set Desire Values

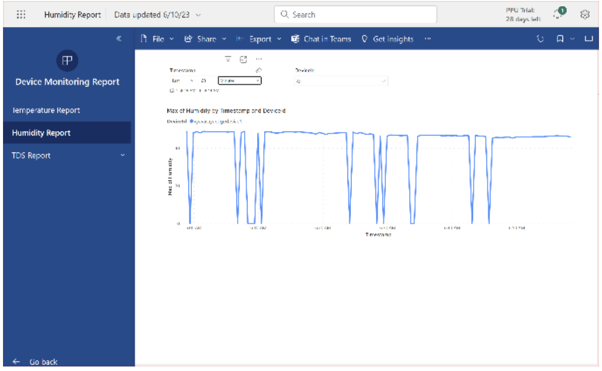

Fig 7. Realtime graph of Humidity

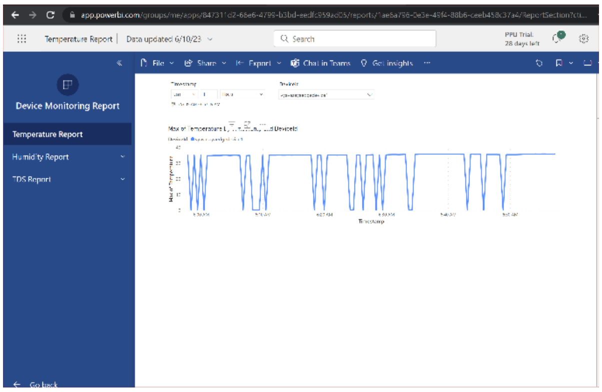

Fig 8. Realtime graph of Temperature

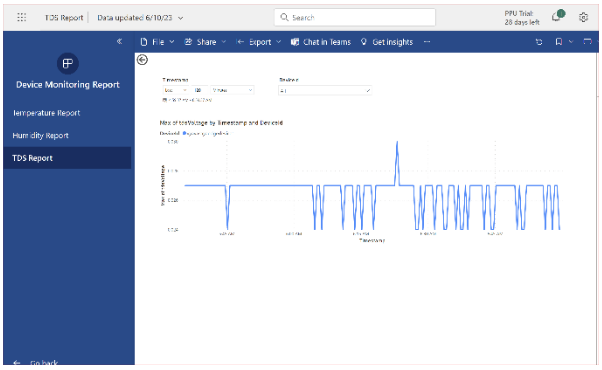

Fig 9. Realtime graph of TDS

5. Discussion

In conclusion, monitoring humidity, temperature, and total dissolved solids (TDS) in hydroponic cultivation is vital for creating and maintaining optimal growing conditions. By closely monitoring these parameters, farmers can optimize plant health, prevent diseases, regulate nutrient uptake, and make informed decisions to enhance crop productivity and quality. The data collected from monitoring humidity, temperature, and TDS provides valuable insights that enable proactive management of the hydroponic system, resulting in higher yields, improved resource efficiency, and sustainable farming practices. Ultimately, the integration of IoT technologies and data analytics in hydroponic cultivation allows for precise control and optimization of the growing environment, leading to increased success and profitability for farmers.

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