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Long-Range Self-Powered IoT Devices for Agriculture Aquaponics

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Abstract: *The aim of this project is to establish a controlled environment in the aquaculture industry by minimizing human errors and reducing the need for manpower. Additionally, the project seeks to enable remote monitoring of aquatic environments from any location in the world. By utilising mobile phone applications, the physical presence of humans can be significantly reduced. The device is capable of collecting and transmitting data from a variety of sensors, including those that measure temperature, humidity, and pH levels. This real-time monitoring and analysis of the aquaponics systems allows farmers and growers to make informed decisions about water usage, fish health, and other productivity-related factors. Ultimately, this system can improve productivity and efficiency in the aquaculture industry. Aquaculture is a growing industry worldwide, and the need for sustainable and efficient practices is increasing. The use of technology and automation has become more common in recent years as a means of improving productivity and reducing human error. The proposed system for aquaculture monitoring aims to address these issues by utilizing sensors and microcontrollers to create a controlled environment for aquatic organisms. The system employs various sensors to measure critical parameters such as water temperature, pH, and turbidity, and sends this data to a central monitoring system. Farmers and growers can then access this data remotely and make informed decisions about the health and productivity of their aquatic systems. This can lead to better control over water quality and temperature, improved feeding practices, and ultimately higher yields*.

Keywords: IoT, Agriculture

I. INTRODUCTION

The Internet of Things (IoT) enables smart devices to connect and interact over a network. IoT has numerous applications, including smart homes, industrial surveillance and automation, healthcare services, and agriculture. Each IoT node consists of a controller unit, transceiver, and sensors or actuators for a specific application. IoT nodes can be powered by cable or batteries, but energy harvesting has become increasingly viable, allowing for years of operation without human intervention. In a wireless IoT network,

trade-offs must be made between energy consumption, bandwidth, and transmission range. By deploying IoT devices in agriculture, critical parameters such as soil pH and nutrient content can be measured, logged, and analyzed for optimal yield. Precision farming techniques can be implemented using IoT nodes to optimize soil sampling and management schemes. In aquaponics, IoT devices can optimize the growth of both fish and plants by measuring and controlling values such as dissolved oxygen percentage and water temperature. This article presents the design and implementation of a fully self-powered, long-range IoT device with a custom ultra-low power (ULP) multi-hop protocol. The article is organized into four sections: device design, measurement results, and conclusion.

The IoT is becoming increasingly popular in agriculture and aquaponics because it allows for real-time monitoring and control of critical parameters, which can improve efficiency, reduce waste, and increase yields. Traditional farming and aquaponics systems rely on manual monitoring and adjustments, which can be time-consuming and inefficient. With IoT devices, farmers and aquaponics growers can monitor and adjust critical parameters in real-time, which can result in significant cost savings and improved yields.

The device designed in this article uses energy harvesting to power the device, which eliminates the need for manual battery replacements or recharging. Energy harvesting devices collect energy from the environment, such as ambient light or temperature differences, and convert that energy into usable electricity. This technology has the potential to revolutionize IoT devices by eliminating the need for external power sources and enabling long-term, maintenance-free operation.

The custom ultra-low power (ULP) multi-hop protocol used in this device is designed to maximize energy efficiency and minimize power consumption. This protocol allows devices in a wireless sensor network to communicate with a gateway while consuming minimal power. By using a multi-hop network topology, the range and coverage area of the device can be extended significantly.

Overall, the IoT has the potential to revolutionize agriculture and aquaponics by enabling real-time monitoring and control of critical parameters. The device designed in this article is an example of how IoT devices can be designed to be fully self-powered, long-range, and energy-efficient, which can result in significant cost savings and improved yields for farmers and aquaponics growers. Long-range self-powered IoT devices for agriculture and aquaponics are becoming increasingly popular as they offer numerous benefits over traditional devices that require frequent battery replacement or wired connections. Here are a few options for such devices:

Solar-powered sensors: These sensors are equipped with photovoltaic cells that capture energy from the sun to power the device. They can be used to monitor temperature, humidity, light intensity, and soil moisture levels. These devices are ideal for use in areas with plenty of sunlight.

Kinetic energy harvesters: These devices generate electricity through motion, such as the movement of a plant or the flow of water. They can be used to power sensors that monitor water levels or water quality in aquaponic systems.

Wireless mesh networks: These networks allow multiple IoT devices to communicate with each other and with a central hub. This means that the devices can be spread out across a large area and still be connected to the network. The network can be powered by a combination of solar, kinetic, and battery power.

Low-power wide-area network (LPWAN) devices: These devices are designed to operate on low power and communicate over long distances. They use technologies such as LoRaWAN or Sigfox to transmit data from sensors to a central hub. These devices can be powered by batteries, solar, or kinetic energy harvesters.

Overall, the choice of long-range self-powered IoT devices for agriculture and aquaponics will depend on factors such as the specific application, the location of the devices, and the availability of power sources. It is important to consider the cost, reliability, and ease of maintenance of the devices when choosing the best option for your needs.

Another option for long-range self-powered IoT devices is kinetic energy harvesters. These devices generate electricity through motion, such as the movement of a plant or the flow of water. They can be used to power sensors that monitor water levels or water quality in aquaponic systems. Kinetic energy harvesters are ideal for use in areas where there is limited sunlight but abundant movement.Long-range self-powered IoT devices are becoming increasingly popular in agriculture and aquaponics. These devices offer several benefits over traditional devices that require frequent battery replacement or wired connections. One popular option is solar-powered sensors. These devices are equipped with photovoltaic cells that capture energy from the sun to power the device.

II. METHODOLOGY

The prototype model utilizes the ESP32 microcontroller and all the sensors are connected to it. The turbidity sensor is responsible for monitoring the presence of dust particles in the pond. It operates by measuring the scattering of light on suspended particles and the resulting reflected light. The water level sensor, on the other hand, is responsible for monitoring the water level in the pond. pH is a critical aspect in aquaculture monitoring as it needs to be maintained within the 5-9 range. A sudden change in pH triggers the outlet water motor to automatically remove water from the pond and replace it with fresh water. The system uses a pH sensor to provide highly accurate readings of the water's pH levels.

The use of a turbidity sensor in this model allows for the early detection of any changes in water quality. This information can help to prevent potential harm to the fish and plants in the pond. The water level sensor, meanwhile, helps to prevent overflows or shortages by constantly monitoring the level of water in the pond.Maintaining the correct pH level is crucial for the success of any aquaponics system. The useof a pH sensor provides accurate and reliable

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measurements of pH levels. This information can be used to determine if any adjustments need to be made to the water in the pond, such as the addition of chemicals or the removal of waste.

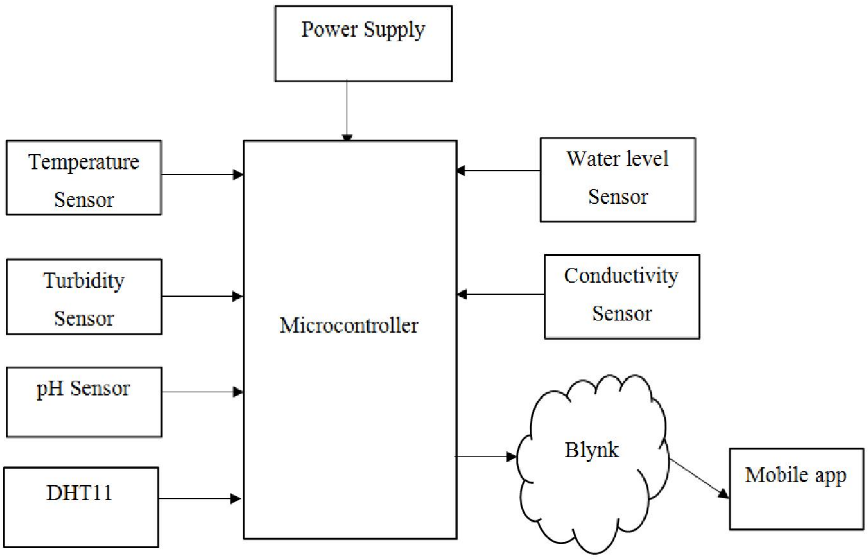

Figure 1 : Block Diagram

Overall, the use of sensors and a microcontroller in this aquaponics monitoring system allows for the efficient and effective management of the pond. It enables the farmer to closely monitor the quality of the water and make necessary adjustments to ensure the health and well-being of the fish and plants in the system.

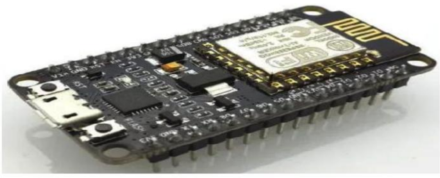

Figure 2: ESP8266MCU

The ESP8266 chip gained a lot of attention from Western makers in August 2014 when a third-party manufacturer, Ai-Thinker, released the ESP-01 module. This module allowed microcontrollers to connect to Wi-Fi networks and establish simple TCP/IP connections using Hayes-style commands. However, the lack of English-language documentation on the chip and its accepted commands made it challenging to use the module at first. Despite the initial challenges, the low price point and minimal external components on the module made it very attractive to many hackers who wanted to explore the chip and its software. They also took the initiative to translate the Chinese documentation, which helped to make the ESP-01 module more accessible to a wider audience. One variant of the ESP8266 chip, the ESP8285, has 1 MiB of built-in flash memory. This upgrade made it possible to build single-chip devices capable of connecting to Wi-Fi networks without needing any additional memory chips. As a result, the ESP8285 chip became even more popular among hobbyists, tinkerers, and developers.

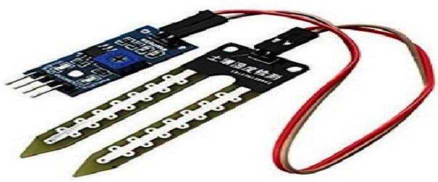

Figure 3: Soil moisture sensor

Soil moisture sensors are used to measure the amount of water present in soil, typically through the measurement of volumetric water content. Direct gravimetric measurement of free soil moisture would require removing, drying, and weighing a soil sample, which is impractical for most applications. Instead, soil moisture sensors indirectly measure the volumetric water content by using another property of the soil as a proxy for moisture, such as electrical resistance, dielectric constant, or interaction with neutrons. The relationship between the measured property and soil moisture must be calibrated, as it may vary depending on environmental factors such as soil type, temperature, or electrical conductivity1.There are several types of soil moisture sensors including tensiometers, capacitance sensors, dielectric sensors, gypsum blocks, volumetric sensors and neutron probes2. Tensiometers measure soil tension when placed in the soil while capacitance sensors measure the water content of the soil using capacitance3. Dielectric sensors also use capacitance to gauge the water content of the soil but they use a different method than capacitance sensors3. Gypsum blocks measure the electrical resistance of the soil and are used to estimate the water content of the soil2. Volumetric sensors measure the amount of water in a given volume of soil while neutron probes measure the amount of hydrogen in the soil which is related to water content2.

III. OBJECTIVES

- The objective of this project is to enable users to monitor an aquaculture system using a mobile application, thus reducing the need for physical presence.
- The system should be self-contained and capable of continuous monitoring of parameters such as pH, temperature, water level, and turbidity to ensure a stable habitat for aquatic creatures and plants.
- The aim is to provide users with the convenience of monitoring their aquaculture from anywhere in the world, without requiring advanced technical knowledge.
- The system should be designed to be easily understood and operated by non-technical users

IV. CONCLUSION

The device has been able to collect and transmit data from various sensors, such as temperature, humidity, and pH levels, to a central monitoring system. This has allowed for real-time monitoring and analysis of the conditions in the aquaponics systems, enabling farmers and growers to make informed decisions about fish health, water usage, and other factors that can impact productivity.IoT devices provide highly accurate data from multiple sensors, allowing farmers and growers to make informed decisions based on real-time information. This can lead to more efficient use of resources and better overall productivity.

As a developing country, India needs to embrace technology to increase its GDP. Aquaculture is a critical sector that contributes significantly to the country's economic growth. Our proposed system aims to improve the quantity and quality of aquaculture production while reducing labor costs through the adoption of automated technology. It is essential to maintain sustained water quality as polluted water can negatively impact the habitat and render it unfit for usage. Various methods can be utilized for the design and implementation of this system, and the integration of internet and Wi-Fi can be leveraged for improved convenience and cost-effectiveness.

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