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Water Utility Conservation and Management Approach Using IoT

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Abstract: The demand for water supply has increased unpredictably worldwide over the past few decades, posing a major challenge. To overcome this challenge, an IoT-based water monitoring and control approach is presented, which supports real-time internet-based data collection. The device comprises a computer system (central hub), an IoT module, a switching unit, and a Zigbee module. The Internet of Things is a network of devices embedded with electronics, software, and sensors that enable them to exchange and analyze data. The centralized hub distributes water individually based on the needs of each household, assisted by IoT integration of communications, control, and information processing across the systems used. This allows water quantity and quality to be sensed at each structure in a particular sector, providing remote access control of the water supply. The centralized hub monitors and shares water among localized tanks or resupplies water from its reservoir according to a rank's deficit or excess water level. Personal area networks are created in this scenario where a wireless connection is required across the system. UV treatment is deployed to improve the quality of water distributed to every household, and fluoride content level along with hardness checking is done using respective test meters. Overall, the IoT-based water monitoring and control approach design presents an innovative solution to the increasing demand for water supply, enabling efficient distribution and ensuring water quality.

Keywords: IoT, Sensor, water management

I. INTRODUCTION

Water is an essential commodity required for the survival of life on Earth, irrespective of its purpose. However, water scarcity has become a major threat to our world. Increasing demand for water supply has become a significant challenge, worsened by wasteful usage of water, climatic changes, and urbanization. The availability of pure water supply has been a matter of concern, particularly in densely populated areas. This paper proposes an IoT-based water control and management system that helps to prevent water crises and enrich pure water.

The IoT module is controlled by concerned authorities to control the excess usage of water. The module includes embedded sensors, microcontrollers, and testers that work together to determine the water level and quality. The data collected by the sensors are stored and processed remotely on a server. The Zigbee protocol is used to enable interconnection and communication between devices. This protocol is designed specifically for use in WPAN and is gaining traction in the Lower Power WAN group. It is inexpensive to run and does not require a lot of power, making it an ideal solution for this issue. A microcontroller is required to carry out all the desired processes, saving surplus amounts of excess water and distributing pure water for the public across a city or particular geographical area.

All these technologies are combined into one module, which enables monitoring and control of water supply and water purification using respective sensors and testers. Therefore, providing this entire module to the hands of the public sector can ensure the proper distribution of safe drinking water over a large metropolitan area. The IoT-based water control and management system proposed in this paper presents an innovative solution to the increasing demand for water supply, helping to prevent water crises and enrich pure water.

II. RELATED WORKS

The central hub is responsible for controlling the water supply in each substation, and the water level sensor in each tank informs the central hub through the Zigbee protocol via the WSN module when a user runs out of water. Zigbee is a protocol specifically designed for control and sensor networks based on the IEEE 802.15.4 standard [1] This paper analyses whether the water in the tank is either more or not meeting the minimum criteria of water in the tank. The central hub further analyses the user's current water level in his tank using an IoT module[2] House level monitoring systems contain the water level sensors and water flow sensors to sense the water level present in a tank and the flow of water rate respectively[3]

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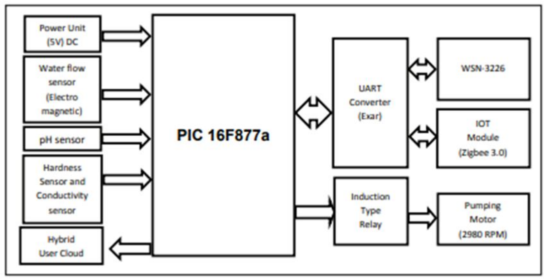
III. SYSTEM ARCHITECTURE

A. Block Diagram For Water Conservation



B. pH Sensor

A pH sensor is an electronic device that measures the acidity or alkalinity of a liquid or solution. pH is a measure of the concentration of hydrogen ions (H+) in a solution, with lower pH values indicating higher acidity and higher pH values indicating higher alkalinity. pH sensors typically consist of a sensing electrode, a reference electrode, and an electronic amplifier or meter.

C. Hardness Sensor

A hardness sensor is a device that is used to measure the level of hardness in water. It determines the number of dissolved minerals such as calcium and magnesium in the water. These minerals can cause scaling or build-up in pipes, appliances, and fixtures which can lead to reduced water flow, inefficient operation of equipment, and damage over time. The hardness sensor works by measuring the electrical conductivity of the water, which is directly related to the concentration of dissolved minerals.

D. Conductivity Sensor

Conductivity is used to measure the ability of a solution to conduct electricity, which is dependent on the concentration of dissolved ions in the solution. Conductivity sensors work by measuring the electrical current that passes through a solution between two electrodes.

E. Water Flow Sensor

A water flow sensor is a device used to measure the rate at which water flows through a pipe or conduit. It typically consists of a paddle or turbine that is placed in the flow of water, and as the water moves the paddle or turbine, it generates a signal that can be used to determine the flow rate.

F. PIC16F877a

PIC16f877a is a popular 8-bit microcontroller chip manufactured by Microchip Technology. It is widely used in various applications, such as embedded systems, robotics, automation, and industrial control systems. The chip contains a Central Processing Unit (CPU), memory, and various input/output peripherals, including timers, interrupt controllers, and communication interfaces. Its programming memory is implemented using flash technology, which allows for the reprogramming of the chip multiple times.

G. Zigbee 3.0

Zigbee 3.0 offers improved interoperability with other wireless protocols, increased data rates, enhanced security, and better power management. It also includes features such as mesh networking, which enables devices to communicate with each other in a self-forming and self-healing network, and support for over-the-air updates, which enables remote firmware updates of devices.

H. Power Unit(5V) DC

A power unit (5V) DC refers to a device that provides direct current (DC) voltage output at 5 volts. This type of power unit is commonly used in electronic devices, such as microcontrollers, sensors, and communication modules. It converts the incoming AC voltage from a power source, such as a wall outlet, into a DC voltage that is suitable for powering these devices.

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I. Pumping Motor (2980 RPM)

Pumping motor RPM (Revolutions per Minute) refers to the rotational speed of the pumping motor, which is the number of full rotations completed by the motor shaft in one minute. The number "2980" likely refers to a specific pumping motor model with a rated speed of 2980 RPM. The pumping motor is used to move fluids, such as water, from one location to another. The rotational speed of the motor determines the flow rate of the fluid, with higher speeds resulting in higher flow rates.

IV. IMPLEMENTATION

The proposed system requires a power supply of 5V for various components such as a PIC16f877a microcontroller, quality sensor, IoT module, pumping motor, WSN module, Zigbee module, and user cloud interface.

A. How PIC16f877a Works

The PIC16f877a microcontroller is a widely used microcontroller that offers convenience and ease of programming in the industry. It has 40 pins, including 33 pins for input and output, and is equipped with FLASH memory technology that allows it to be programmed and erased multiple times. Its large programming memory of 8k words and 368 Bytes of RAM makes it capable of handling many tasks efficiently. Additionally, it can be powered through a USB cable, AC-to-DC adapter, or battery, making it easy to use and flexible. The system needs to transmit data online to enable real-time monitoring of the water supply system. This is made possible with the help of a Wireless Sensor Network (WSN) module. The WSN module allows the microcontroller to access the Bluetooth network, enabling the system to transmit data in real time.

B. How Zigbee 3.0 Works

The Zigbee protocol is used for data transfer in the proposed system. Zigbee data transfer is done in non-beacon mode and beacon mode. In non-beacon mode, devices go into sleep mode when not communicating, and the coordinator and router only wake up when data needs to be transmitted. This mode consumes less power, and most devices remain inactive for long periods, making it an efficient power-saving mode. In beacon mode, however, coordinators and routers continuously monitor incoming data, resulting in higher power consumption. In this mode, devices do not sleep, as any node can wake up and communicate at any time.

V. RESULT

pH	6.5 to 8.5
Nitrates	<10 mg/l as NO3-N
Magnesium	>125 Mg/l
Manganese	0.07-0.12 mg/l
Calcium	>130 mg/l
Iron	<0.3 Mg/l
Total Hardness	<170 mg/l

Our study states that in drinking mineralized water, magnesium can lower blood pressure. We use several types of sensors to measure the quantity of these minerals present in the water and other factors such as the pH and hardness of the water. But there is no assurance that the supplied water would be pure enough for domestic and commercial purposes. Hence we use various types of sensors and mineral cartridges to monitor and alter the quality of the water to make it better. The Substation has various filters like RO systems, UV treatment systems, and sedimentation tanks which purifies the water to a point where the impurities and excess amount of minerals are removed. Also during this purification process, the essential mineral content (as per the given table) is lost. In recent surveys, an average human needs around 3 liters of mineralized water. But comparing this quantity to actual domestic purposes, it is very minimal in usage. Hence, the usage of Mineral cartridges is minimalized. Now let us discuss minerals and other factors that affect the purity content id water. One of the most important factors that affect water purity is The hardness of the water. Water hardness is an aesthetic quality of water, and is caused mostly by the minerals calcium and magnesium, but is classified or measured based on the level of concentration of calcium carbonate. The water hardness sensor includes a sensing matrix in contact with the flow of water, an indicator that is used for analyzing calcium carbonate and magnesium content. We get the actual content of hardness present in the water. Hard water can be classified into moderately hard (60-120 mg/L), hard as well as very hard water (>120 mg/L). Moderately hard water can be used for domestic purposes and apt of drinking water too. Very hard water is used for industrial purposes. Another factor that affects the quality of the water is the pH value of the water.

For this, we use a pH sensor that estimates the hydrogen content in the water and gives the acidic or basic nature of the water according to the pH value. We can control these two factors by purifying the water using an RO system which can be placed at both substation and house levels. Now, we use Mineral cartridges to control the mineral content of the purified water in the substation. After the purification process, the water mineral content is reduced. This water is good enough for both commercial and industrial purposes but not apt for drinking and cooking purposes. Hence we use mineral cartridges at the house level to replenish the mineral contents lost during purification processes. As said before, the use of mineralized water is way too low when compared to commercial purposes. Thus the installation of the mineral cartridge is based on specific needs and requirements. Thus by using our model we can monitor the quantity and quality of the water as well as improve it by various controlled purification systems such as UV and RO processes and mineral replenishment.

VI. CONCLUSION

This paper has given a brief discussion about smart water supply across a particular area by harnessing the technological usage of the IoT concept, simultaneously Improving the Water quality of the Drinking Water. This idea could be implemented by various governments across the world to save the water bodies from drying up caused by excess water usage. This system can also be implemented to reuse the water also to prevent water wastage. The Purification and Conductivity test of water also plays a huge role in the welfare of the public. This could reduce the overall Disease caused due to deficiency, thus creating a healthier society of people. This system can also be further enhanced by including modules that could improve the given situation further to prevent the excess usage of water and save the Underground water table.

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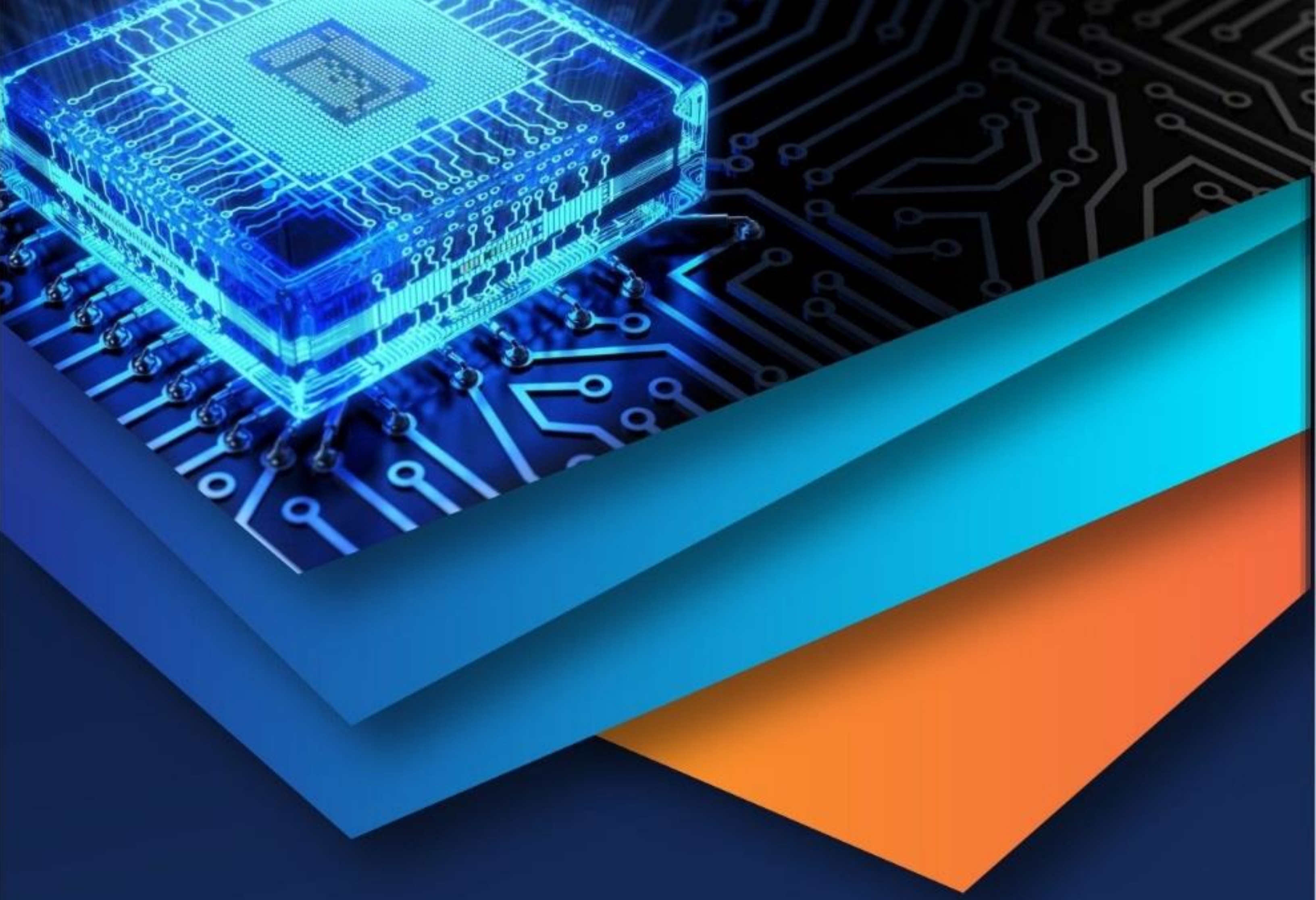

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