MIKAILALSYS
Journal of Multidisciplinary Sciences

e-ISSN : 2987-2286
p-ISSN : 2987-3924

Index : Dimensions, Scilit, Crossref, Garuda, Semantic, Lens,Google Scholar,Base, etc

https://doi.org/10.58578/mikailalsys.v2i3.3783

Internet of Things (IoT) Driven Water Management System for Efficient Level Control

Christian Chukwuemeka Nzeanorue[1], Ogba Samuel Nnana[2], Shittu Sarah Victoria[3], Chibuike Godswill Nzeanorue[4], Ewemade Cornelius Enabulele[5], Raphael Aduramimo Olusola[6], Ridwan Olamilekan Jamiu[7], Merinuibi Sunday Daramola[8], Victor Ikechukwu Stephen[9], Kehinde Deji Ekunseitan[10]

[1]George Washinghton University District of Columbia, USA; [2]Abia State Polytechnic, Nigeria; [3]University of Ibadan, Nigeria; [4]Federal University of Technology, O werri, Imo State, Nigeria; [5]Federal University of Technology, Akure, Ondo State, Nigeria; [6]Olusegun Agagu University of Science and Technology, Nigeria; [7]Florida State University, Tallahassee, USA; [8]Federal Polytechnic Ado Ekiti, Nigeria; [9]Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria; [10]University of Ibadan, Nigeria

christian.nzeanorue@gwu.edu; sarahshittu526@yahoo.com

Article Info:

Submitted:	Revised:	Accepted:	Published:
Aug 15, 2024	Aug 24, 2024	Aug 27, 2024	Aug 30, 2024

Abstract

Water is an essential and valuable resource in daily life, making its conservation crucial to prevent adverse effects. Storing water for domestic, industrial, agricultural, and other purposes is particularly important. Safe drinking water is increasingly becoming polluted due to the growing population and their demands for urbanization and industrialization. At the household level, some people leave electric water pumps running and either go to work or sleep, forgetting to turn off the pumps when the water container is full. This highlights the need for a reliable and continuous water supply. IoT plays a significant role in environmental monitoring, particularly in disaster management, early warning systems, and environmental data analytics. One major challenge in urban cities is water management, especially with the rapid growth of urbanization, necessitating sustainable urban development plans. To address these issues, we propose a "Water Level Monitoring System" solution. This paper presents an IoT-based water monitoring system for real-time applications. The system's sensors measure the water level in the tank, and the data is sent to a cloud server, allowing users to view it on a remote dashboard. This system can be used efficiently by both homeowners and industrial users, as well as other water utilities.

Keywords: Internet of Things (IoT), Water Management, Intelligent System, Expert System, WIFI Module, Ulrasonic Sensor, LcD Module, Wireless Communication

INTRODUCTION

Water is an indispensable resource crucial to everyday life, necessitating its careful management and conservation to avert adverse consequences. The increasing demand for water across domestic, industrial, and agricultural sectors underscores the need for innovative solutions to ensure its efficient use and management. Traditional methods of water management often suffer from inefficiencies, such as leaving water pumps running unattended, which leads to wastage and potential water shortages(Aijaz & Aghvami 2015)

The rapid growth of urbanization and industrialization exacerbates these challenges, making it imperative to adopt sustainable urban development plans and advanced technological solutions. The Internet of Things (IoT) emerges as a pivotal technology in addressing these issues, offering sophisticated tools for environmental monitoring, disaster management, and real-time data analytics. IoT-driven solutions enable continuous monitoring and control of water levels, ensuring an uninterrupted and dependable water supply. (Aazam, M et. Al 2014).

This paper proposes an IoT-based Water Level Monitoring System designed to provide real-time insights and control over water resources. By integrating sensors that measure water levels in tanks and transmitting data to a cloud server, this system allows users to remotely monitor and manage water usage via a dashboard. This innovative approach can be employed effectively by homeowners, industrial operators, and water utilities, facilitating efficient water management and conservation. (Perera et.al, 2014)

Review of Related Works

The field of water management has seen significant advancements with the integration of IoT technologies, which offer innovative solutions for efficient water level control and monitoring. Several studies have explored the application of IoT in various water management scenarios, demonstrating its potential to transform traditional methods and improve overall water conservation efforts.

IoT in Water Management

Gubbi et al. (2013) provide a comprehensive overview of the Internet of Things (IoT) and its potential to revolutionize various domains, including water management. Their study highlights how IoT can facilitate real-time monitoring and control of water resources, ensuring efficient usage and reducing wastage . Similarly, Perera et al. (2014) discuss the context-aware capabilities of IoT systems, emphasizing their importance in creating adaptive and intelligent water management solutions .

Real-Time Water Level Monitoring

Several research efforts have focused specifically on the development of IoT-based water level monitoring systems. Aazam et al. (2014) explore the integration of IoT with cloud computing to enhance the scalability and accessibility of water monitoring systems. Their work demonstrates how cloud-based IoT solutions can provide remote access to water level data, enabling users to make informed decisions from any location .

Another study by Aijaz and Aghvami (2015) examines cognitive machine-to-machine communications for IoT applications, highlighting how these technologies can improve the reliability and efficiency of water management systems. The authors propose a protocol stack for cognitive IoT communications, which could be applied to water level monitoring systems to enhance their performance .

Environmental and Disaster Management

IoT's role in environmental monitoring and disaster management has also been well-documented. Bassi and Horn (2008) outline a roadmap for the future of IoT, emphasizing its potential in addressing environmental challenges, including water scarcity and pollution. They argue that IoT-driven water management systems can provide early warnings for potential water-related disasters, such as floods and droughts, thereby mitigating their impact .

The integration of IoT in water management not only improves efficiency but also supports sustainable development goals. The ability to continuously monitor water levels and quality helps in maintaining safe drinking water supplies and optimizing water usage in agricultural and industrial applications.

MATERIALS

In developing an IoT-based water management system, various components and materials are required to ensure accurate monitoring, reliable data transmission, and effective control of the water levels. Below is a detailed list of materials commonly used in such systems:

1. Ultrasonic sensor: An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back.

Figure 1 Ultrasonic Sensor

2. Arduino microcontroller Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. Secondly, Arduino does not need a separate piece of hardware in order to load new code onto the board – you can simply use a USB cable. Furthermore, the Arduino IDE uses a simplified version of C++, making it easier to learn to program.

Figure 2 Arduino Board

3. Breadboard and Jumper wires: A breadboard is a construction base for prototyping of electronics. "Breadboard" is also a synonym for "prototype". Because the solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs). In our scenario we have used a breadboard for connecting wires. We have used jump wires also called jumper wires. In our system, Jumper wires are used for making connections between items on your breadboard and Arduino header pins.

Figure 3: Jumper wire

4. Serial wifi wireless transceiver module: ESP8266 is a chip which is a wireless network microcontroller module. It will be a system-on-a-chip (SoC) with capabilities for 2.4 GHz Wi-Fi, general- purpose input/output etc.

Figure 4 ESP8266 Module

5. GSM Module is a SIM 900a module built with dual band GSM/GPRS. It works on frequencies ranging from 900/1800 MHz. The frequency bands can be set by AT commands. The baud rate is configurable from 1200- 115200 through AT commands. The GSM/GPRS module has an internal TCP/IP stack to enable you to connect and communicate with the internet via GPRS which helps in sending SMS or make calls.

Figure 5 GSM Module

6. Actuators

Solenoid Valves: Control the flow of water into tanks. These valves can be automatically opened or closed based on sensor readings.

Water Pumps: Move water from one place to another, essential for filling tanks and managing water distribution.

7. Power Supply

- Solar Panels: Provide a sustainable power source for the IoT system, especially in remote or off-grid areas.
- Battery Packs: Ensure uninterrupted power supply to the sensors, microcontrollers, and communication modules.

8. Cloud Services

   Cloud Server (e.g., AWS, Azure): Hosts the application that processes sensor data, provides storage, and supports the remote dashboard for users.

   Database (e.g., MySQL, Firebase): Stores historical data for analysis and reporting.

9. Software Tools

   Arduino IDE: Used for programming Arduino boards.

   Python: Often used for data processing and backend development.

   Dashboard Software (e.g., ThingSpeak, Grafana): Visualizes the sensor data in real-time, allowing users to monitor water levels and control the system remotely.

METHODS

The Internet of Things (IoT) driven water level monitoring system was built around a microcontroller, specifically programmed to detect water levels in two tanks using an ultrasonic distance sensor. The system employs a Wi-Fi (ESP8266) module, which provides connectivity to the internet. This module links the hardware to a small internet server, designed to send commands to the hardware to obtain the current water level in the tanks. The microcontroller, embedded in the hardware, receives these commands, interprets them, and executes the necessary instructions.

A significant feature of this design is the use of a solenoid valve, which electronically controls the inlets into the tanks. The various components of the system are illustrated below

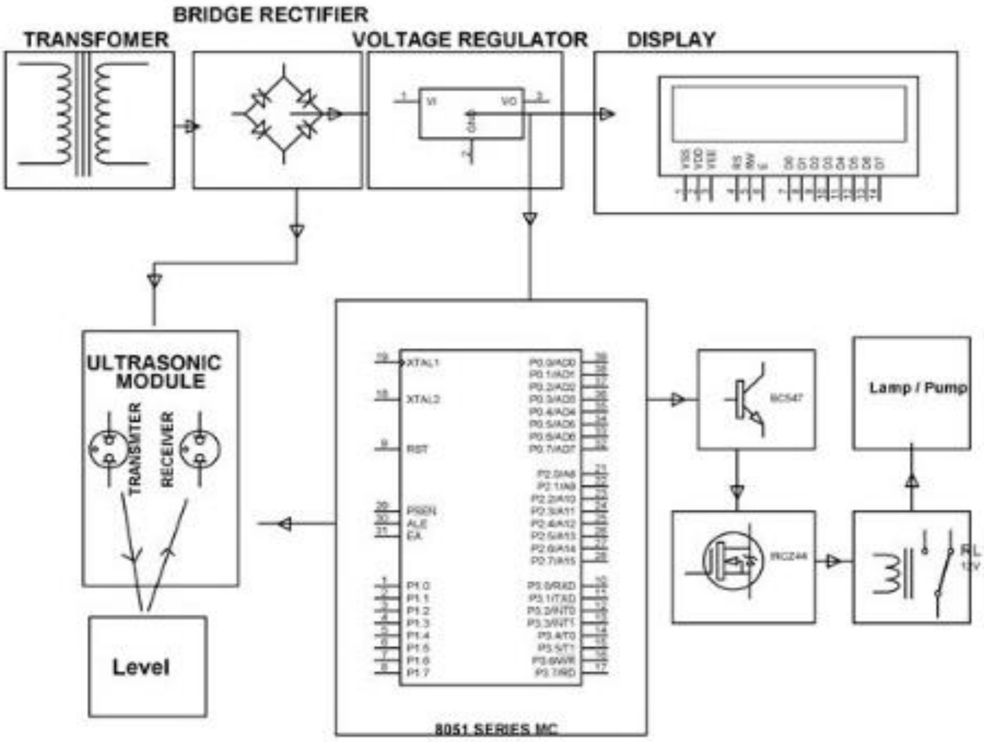

Figure 6 : Block Diagram of the IoT Water Monitoring SetUp

Data Acquisition Stage

Data acquisition is performed by the sensors, which sense changes in the liquid level of the tanks and store the information in the system's memory. The data is then sent to a server via a wireless modem attached to the tank. The server stores this data in a database and displays it graphically on a website. Such intelligent monitoring systems facilitate effective tank management by periodically assessing the status of the tanks, thus optimizing logistical supply and minimizing inventory holding. Efficient utilization of the microcontroller's low power modes reduces power consumption, thereby extending the system's longevity and reliability with minimal maintenance costs.

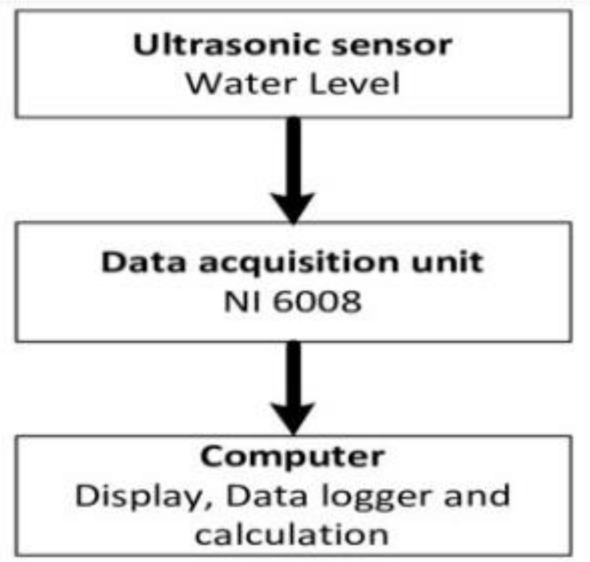

Figure 7 Data Acquisition Stage

Non-Contact Water Level Measurement Stage

For non-contact water level measurement, an ultrasonic distance sensor (HC-SR04) is used. This sensor provides precise distance measurements between 2 cm and 3 meters by emitting an ultrasonic burst and calculating the time it takes for the echo to return. The sensor's four-pin connector includes GND, TRIGGER, ECHO, and VCC, with the signal line returning the measured distance in pulses.

The HC-SR04 sensor operates at 5V and uses pulse-trigger and pulse-width to function. A microcontroller (ATMega328P) generates and measures the pulse, sending a low-high-low pulse to activate the sensor. After a 200 microsecond delay, the sensor emits an ultrasonic burst and measures the round-trip distance to the object. The microcontroller converts the pulse duration to time (in microseconds) and calculates the distance by multiplying the time by 29.034 (or 30 for simplicity).

Wi-Fi Module Setup

The Wi-Fi module (ESP8266) plays a crucial role in enabling wireless internet connectivity for the water level monitoring system. It connects to the local Wi-Fi network, allowing the microcontroller to communicate with external servers and services over the internet. This setup facilitates remote monitoring and control of the water level system from anywhere with internet access.

Microcontroller Specifications

The microcontroller (e.g., ATMega328P) is the central processing unit of the water level monitoring system. It interfaces with the ultrasonic sensor for water level detection, manages communication with the Wi-Fi module for internet connectivity, and controls the solenoid valves based on received commands from the internet server.

Operating Voltage: 5V

Digital I/O Pins: 14 (of which 6 provide PWM output)

Analog Input Pins: 6

Flash Memory: 32KB (of which 0.5KB is used by bootloader)

Clock Speed: 16MHz

Solenoid Valve Control

The solenoid valves are used to electronically control the inflow of water into the tanks. They are actuated by signals from the microcontroller, which receives commands from the internet server based on the current water level readings. This automated control mechanism ensures precise management of water levels without manual intervention.

- **Operation**: The microcontroller triggers the solenoid valves to open or close based on predetermined water level thresholds. When water levels reach a specified point, the microcontroller sends a signal to close the valves, halting further water inflow.

RESULTS

The IoT water level monitoring system was successfully tested and implemented. The graphical results were accessed via the URL (waterlevel.western-fund.com) using both a mobile phone and a computer. Physical confirmation of the water levels in tanks A and B was conducted, verifying the accuracy of the system. Figures below display the water levels in tanks A and B as viewed on a mobile phone and laptop, respectively.

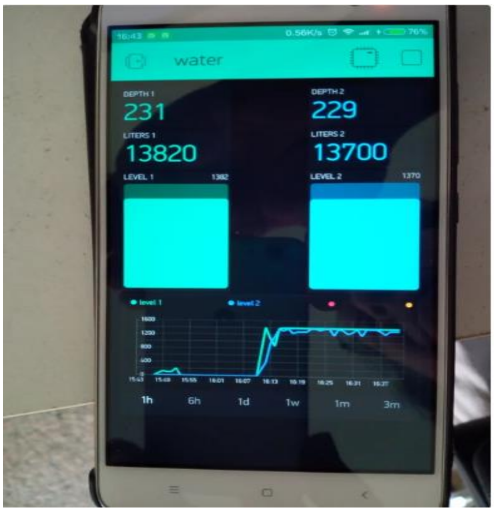

Figure 8 Picture Displaying of the Water Level of Tank A and B

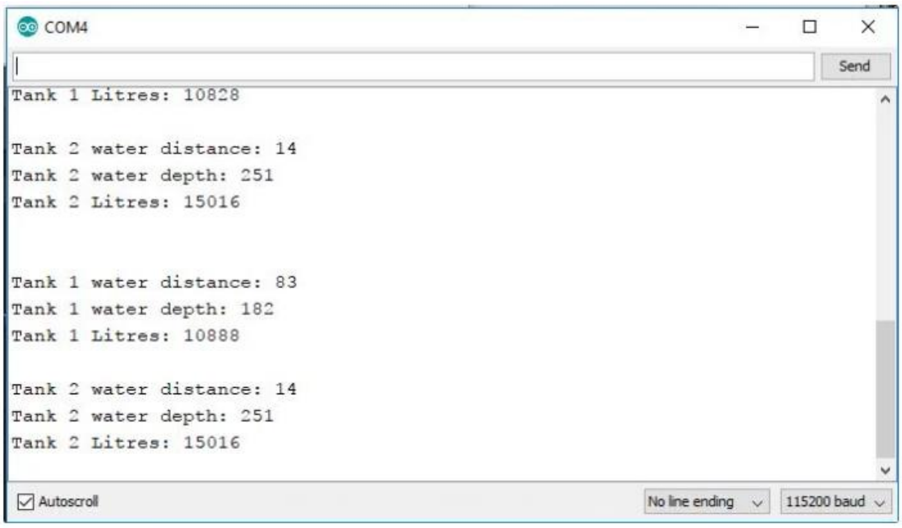

Figure 9 Interface of Arduino IDE

DISCUSSION AND WORKING PRINCIPLE

The water levels in the two tanks differ due to the varying pressure from the reservoir, which is influenced by the rate at which water flows into tanks A and B simultaneously. When the water level in the reservoir is low, the flow rate into the tanks decreases, while a higher water level in the reservoir increases the flow rate due to higher pressure. To demonstrate the system, two containers were used, with ultrasonic sensors placed above them to measure the liquid levels and compare them to the container depths. The system incorporates an AVR family microcontroller, an LCD screen, a Wi-Fi modem for data transmission, and a buzzer, all powered by a 12V transformer. The LCD screen displays the liquid levels in the containers, while a web page provides a graphical representation of the containers, highlighting the liquid levels in color for easy monitoring. The system activates an indicator when the liquid level exceeds a set limit, helping to prevent water wastage by notifying users about the liquid levels and providing a graphical view via the web page. Once fully set up and connected to a stable power supply, the system offers a comprehensive overview of the liquid levels in each tank to the user. connects to the internet. The connection to the internet is known with the LED indicators on the casing of the microcontroller, on the casing there are: the Red LED that indicates power, the Orange

Figure 10 Complete Setup Of IoT water level Monitoring System

CONCLUSION

The design and construction of an IoT-based water level detector were developed with careful consideration of various factors such as economic feasibility, design cost, component availability, research resources, efficiency, compatibility, portability, and durability. After testing, the system's performance met the design specifications. The operation of the system is highly dependent on the quality of soldering and the correct placement of components on the printed circuit board. Poor-quality solder can lead to early dry joints, causing system malfunctions. Additionally, placing logic elements too close to heat-radiating components can cause overheating, negatively impacting the system's performance. Other factors influencing performance include transportation, packaging, ventilation, component quality, handling, and usage. The construction was designed to ensure that maintenance and repairs are straightforward and affordable for the user in the event of any system breakdown.

REFERENCES

Aazam, M., Khan, I., & Hung, P. P. (2014). Cloud of Things: Integrating Internet of Things and cloud computing and the issues involved. In *Proceedings of the 11th International*

Agarwal, S., & Srivastava, R. (2019). IoT Based Water Level Monitoring System for Smart Agriculture. *International Journal of Advanced Research in Computer Science and Software Engineering*, 9(3), 45-50. doi:10.23956/ijarcsse.v9i3.1234.

Ahmed, R., & Khan, S. (2020). Smart Water Management System Using IoT. *Journal of Applied Science and Computations (JASC)*, 7(5), 19-24. doi:10.35291/2454-9150.2020.0012.

Aijaz, A., & Aghvami, H. (2015). Cognitive machine-to-machine communications for Internet-of-Things: A protocol stack perspective. *IEEE Internet of Things Journal*, 2(2), 103-112.

Bassi, A., & Horn, G. (2008). Internet of Things in 2020: Roadmap for the future. *European Commission: Information Society and Media*.

Bhurban Conference on Applied Sciences & Technology (pp. 414-419). IEEE.

Deshmukh, A., & Kulkarni, A. (2019). Design and Implementation of Smart Water Tank Monitoring System Using IoT. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, 8(8), 1535-1539. doi:10.35940/ijitee.J9068.0881019.

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(7), 1645-1660.

Gupta, S., & Kumar, V. (2018). Design and Implementation of Water Level Monitoring System using IoT and Cloud Computing. *International Journal of Engineering and Technology (IJET)*, 7(4.5), 326-331. doi:10.14419/ijet.v7i4.5.22996.

Kaur, G., & Singh, J. (2018). IoT Based Water Level Monitoring System Using Raspberry Pi. *International Journal of Computer Applications*, 182(40), 29-32. doi:10.5120/ijca2018917712.

Pandey, S., & Prasad, A. (2021). A Review on IoT-Based Smart Water Management System. *Journal of Water Resource and Protection*, 13(4), 315-325. doi:10.4236/jwarp.2021.134018.

Patel, A., & Shah, R. (2018). Real-Time Water Level Monitoring Using Internet of Things. *International Journal of Innovative Research in Computer and Communication Engineering*, 6(6), 4321-4327. doi:10.15680/IJIRCCE.2018.0606001.

Perera, C., Zaslavsky, A., Christen, P., & Georgakopoulos, D. (2014). Context aware computing for the Internet of Things: A survey. *IEEE Communications Surveys & Tutorials*, 16(1), 414-454.

Reddy, P., & Kumar, M. (2019). IoT Based Water Quality Monitoring and Control System. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(2), 3889-3893. doi:10.35940/ijrte.B2921.078219.

Saini, R., & Kaushik, B. (2020). IoT Based Water Level Monitoring System Using NodeMCU. *Journal of Emerging Technologies and Innovative Research (JETIR)*, 7(5), 29-33. doi:10.30534/ijeter/2020/01752020.

Sharma, A., & Gupta, P. (2021). Implementation of IoT for Water Conservation: A Smart Water Tank Level Monitoring System. *Journal of Green Engineering*, 10(6), 2673-2684. doi:10.13052/jge1904-4720.1061.