International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
IJISAE
ISSN:2147-6799 www.ijisae.org Original Research Paper

Innovations in Smart City Water Supply Systems

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Submitted: 25/04/2023 **Revised**: 25/06/2023 **Accepted**: 06/07/2023

Abstract: This research offered a concept that makes use of Internet of Things (IoT) technology to provide automated distribution and consumption control as well as real-time monitoring of water supply and quality. Using Arduino microcontrollers and sensors enables the development of a scalable, affordable solution that may be used in a number of smart city applications. The potential advantages of the suggested approach are also highlighted in the article, including better water conservation, decreased waste, and higher water distribution efficiency. Additionally, the difficulties and restrictions of putting such a system into practise are discussed, and recommendations for further study and development in this area are given.

Keywords: *Innovations, Smart City, Water Supply, Automated System, Technology, Arduino, Database, Water Management.*

1. Introduction

The idea of a "smart city" is revolutionary in that it seeks to transform how people live and engage with their surroundings. This shift is being driven by the Internet of Things (IoT), a critical technology that makes it simple to access and communicate with a variety of smart devices. These gadgets include traffic management systems, smart household appliances, surveillance cameras, and more. Water management is one of the issues that smart cities must deal with, though. Life depends on water, and the water supply system is crucial in ensuring that everyone has access to enough water of the proper quality and pressure.

In this research, an IoT-based approach is suggested for enhancing water management in smart cities. The suggested remedy is creating a fundamental architecture for the water distribution system, as displayed in Figure 1. Data about water supply and usage are collected and analysed using sensors and other devices that are part of the system. The necessary amount of water is then calculated for each place using the data once it has been processed and analysed. This strategy guarantees that water is not wasted and that the water supply system is effective [1].

The suggested approach can optimise water use, cut down on waste, and guarantee that everyone has access to enough water, among other advantages. The solution is also adaptable and scalable to fit the requirements of various smart cities. IoT is set to play an ever bigger part in the management of water resources in smart cities as technology advances, resulting in more sustainable and effective water use.

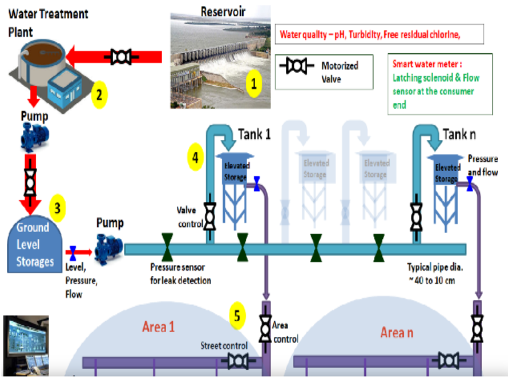

Fig. 1. Architecture of water supply[2].

A further important issue in water management is the quality of the water. Water quality needs to be constantly monitored and maintained because it can cause a number of health problems. Water quality factors including pH levels, temperature, turbidity, and dissolved oxygen may all be monitored in real-time using IoT-based devices. This information can be examined to find any problems with the quality of the water and take the necessary steps to resolve them [3].

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In addition to monitoring and management, smart cities can employ IoT to conserve water. IoT sensors can be used in smart irrigation systems to keep track of the weather, soil moisture levels, and plant water needs. The ideal amount of water needed for irrigation may be calculated using this data, considerably decreasing water waste. Additionally, IoT-enabled water recycling systems can reuse wastewater for things like gardening and toilet flushing that aren't potable, lowering the overall need for freshwater.

Additionally, by improving the effectiveness, dependability, and sustainability of the water supply system, IoT has the potential to revolutionise water management in smart cities. To overcome these obstacles and put creative solutions for water management in smart cities into practise, stakeholders including government organisations, water utilities, and technology companies must work together [4].

In a smart city, residents live in a variety of homes, and depending on their needs, each household may use a different amount of water. For instance, compared to weekdays, winters, and rainy seasons, when water usage is normally lower, weekends and summers typically see increased water usage. Therefore, it is essential to manage the water supply in a smart city to prevent overflow and give residents the necessary amount of water. These needs can't be met by the current water supply system. The suggested method uses IoT sensor devices to reduce waste and give families the right amount of water in order to meet these limits. By using this system, the water supply can be controlled based on the specific requirements of each household, leading to efficient use of water resources in a smart city.

2. Related Work

SMW can reduce water losses, decrease energy consumption, and enhance the water supply system's resilience to climate change. It can also lead to the creation of new jobs in the water sector and stimulate innovation in the development of new technologies. SMW can encourage water conservation methods while enhancing consumer access to and affordability of water. Cities can enhance their water management skills and maintain the sustainability of their water resources by incorporating SMW into the current water supply system. However, SMW implementation calls for sizable infrastructure and technology investments, as well as appropriate governance and policy frameworks. In order to ensure the successful implementation of SMW in smart cities, it is essential that numerous stakeholders, including as government organisations, the corporate sector, civil society, and academia, are involved [5].

In addition to the water management system's current capabilities, there are a number of areas where cutting-edge technology can be used to boost the effectiveness and sustainability of the system. Artificial intelligence (AI) integration, for instance, enables predictive maintenance of the water distribution network, enabling early detection of possible difficulties and pro-actively preventing any supply disruptions.

Additionally, machine learning algorithms can be used to forecast future demand and analyse historical usage patterns to optimise water supply and distribution. Additionally, the use of blockchain technology can ensure the secure and effective transfer of data between various stakeholders, bringing transparency to the water supply chain. The energy consumption of the water management system can also be greatly reduced by the use of renewable energy sources, such as solar power, making the system more environmentally friendly and sustainable. In light of increasing urbanisation and population expansion, the continuing investigation and application of cutting-edge technology in the water management system may result in a more effective, long-lasting, and dependable water supply for communities.

The three tier architecture of IoT is explored by [6], which includes the bottom tier, network tier, and top tier. The bottom tier consists of various objects and things, such as personal mobile devices, actuators, and sensors. The network tier is responsible for transmitting the data generated by the things and can be wired or wireless for reliable transmission. The top layer, also known as the application layer, manages and analyzes the data collected and presents it to end-users in the form of knowledge rather than raw information. This architecture is essential in the development of efficient and effective IoT systems that can enhance the management of various resources, including water, in smart cities..

In a recent study, the authors compared several wireless technologies such as XBee, Bluetooth, and Wi-Fi, to determine which technology is most suitable for implementing the Internet of Things (IoT) [7]. In addition to wireless sensors, addressing systems and RFID, XBee emerged as a highly advantageous technology for IoT applications. It boasts several benefits, such as better range coverage, lower power consumption, and better latency when compared to other technologies. The XBee also wakes up from sleep mode in 15 ms, which is much faster than Bluetooth's 3-4 second wake-up time. The authors noted that XBee technology employs high three-tier security protocols, such as ACL or AES, making it a highly secure option for IoT applications. The comparison of these wireless technologies was based on several variables, including operating band, travel distance, and power consumption.

The article [8] highlights three significant issues in the wireless communication of the IoT: data challenges, transmission issues, and power issues. Various wireless communication options such as Wi-Fi, Device-to-device communication, satellite, and mobile broadband communications are available for IoT devices. The recommended approach for wireless communication in a mesh network, as proposed by [9], is ideal when the distances between sensing devices are uniform. In a mesh network, each device serves as the next device's communication hub, thereby facilitating reliable transmission of data. One significant challenge in wireless communication is the power requirements of the device that uses a wireless technology or a wireless protocol. This issue must be addressed to ensure that the devices can transmit data efficiently without running out of power.

Each device needs a distinct address as the number of devices connecting to the internet rises. Use of the IPv6 addressing system is advised and explained in [10] to meet this demand. The IPv6 addressing system offers a significantly wider address space than the IPv4 addressing system, making it possible to allocate an almost unlimited number of unique addresses. Additionally, IPv6 allows for automatic address configuration, which makes it simpler for devices to connect to the network without requiring manual configuration. Additionally, IPv6 offers improved security features like IPsec, which is a part of the protocol. In light of the fact that IPv6 addressing allows for seamless device connectivity and communication, adopting it is crucial for the effective operation of the Internet of Things (IoT).

The application platform is frequently made available as a service in the present era of cloud computing, known as Platform as a Service (PaaS). This environment shields developers from the underlying infrastructure, allowing them to launch applications with little effort. The Internet of Things (IoT) is supported by a number of top cloud platforms, including IBM Bluemix [11], Ubidots [12], Carriots [13], Nimbits [14], and Thingspeak [15].

These cloud platforms offer a variety of tools and services to developers, such as data storage, analytics, and visualisation options. Ubidots, for example, enables developers to construct dashboards for visualising data gathered from IoT devices. Similar to IBM Bluemix, IoT applications can take advantage of a variety of services from IBM Bluemix, including data analytics, cognitive computing, and machine learning. Contrarily, Thingspeak offers programmers a free platform for IoT analytics and data visualisation..

Scalability, adaptability, and cost-effectiveness are just a few advantages that cloud platforms for IoT applications can provide. Without having to worry about managing the underlying infrastructure, developers may simply scale their apps as demand increases by employing cloud-based services. Additionally, pay-as-you-go pricing models are frequently offered by cloud-based platforms, enabling developers to only pay for the resources they actually use.

3. Methodology:

Using Arduino and sensor devices, a proposed model for managing water supply in smart cities has been created and put into practise. This model's primary goal is to guarantee that consumers in smart cities always have uninterrupted access to the necessary amount of water. In order to do this, data is gathered using a very effective computer component called an Arduino. Arduino is more dependable and better suited for interacting with sensors and processors in real-time applications than other hardware components. The water supply management system functions more efficiently and lasts longer thanks to the usage of Arduino. Users in smart cities will have constant access to clean water thanks to the deployment of this paradigm, which will enhance their quality of life.

A main station that manages a number of sub-stations tasked with monitoring and controlling water distribution in a smart city is the proposed approach for managing water supply. The system makes sure that every house and region receives the same amount of water because each sub-station is directly connected to a group of homes. To accomplish this, each water tank has a sensor chip installed to track the water level and identify any waste. The main station and sub-stations receive the sensor data for processing, which enables the system to deliver the right amount of water to each home.

By regularly checking the water level in each tank, the sensor chips employed in this model play a critical role in guaranteeing effective water management. The technology may modify the water flow rate to prevent waste and guarantee that every house receives the same quantity of water by sensing any changes in water levels. The risk of water shortages or overflows, which can cause major losses in water resources, is reduced with the aid of sensor chips.

Each sub-station is in charge of a particular neighbourhood of homes, and the sub-stations are carefully positioned to provide optimal water distribution. This makes it possible for the system to react rapidly to any problems that may develop and for the water supply to be swiftly modified to meet the shifting needs of the smart city. With this paradigm, the problem of no water available for use is removed, and residents in smart cities can benefit from a consistent and stable supply of water.

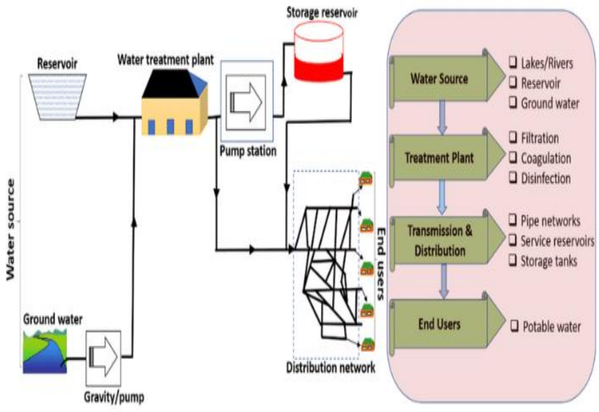

Fig. 2. Block diagram for the proposed model

The suggested model includes a database where the amount of water needed by each residence is stored in order to guarantee that families receive an adequate supply of water. This guarantees that there won't be any water wastage owing to an abundance or shortage due to a lack of supply. Every time a home needs water, the amount is pulled from the database, and the Corporation then provides enough water for that specific home. The technology ensures that each house receives the necessary amount of water and does away with the need for personal intervention. Additionally, by doing this, the smart city uses less water overall and helps to conserve water resources.

4. Results:

An effective water management system starts with data collection at Points of Use (PoUs), which can be any place where water is utilised, including homes, workplaces, or public spaces. Each PoU is equipped with four level sensors that capture crucial information about the water level. These level sensors are utilised to collect the data. To analyse and analyse the data, a central system receives it from the sensors.

The data is retrieved from the database and processed on an Arduino board in the second stage. The data from the sensors is received by the Arduino board, which then processes it in accordance with the needs of the system. The system's web servers run on the Debian operating system, and the data is stored in a MySQL database.

The sensors output a value of TRUE if there is enough water supply and FALSE otherwise. This makes it possible for the system to calculate how much water is provided to each residence and ensures that an excessive or inadequate supply of water may be avoided. Water may be used more effectively if it is made available to every family in an acceptable quantity with no wastage.

In conclusion, a successful water management system requires the collection of data from points of use (PoUs) and its subsequent processing by sophisticated technologies such sensors, microcontrollers, and databases. The system minimises wastage, hence increasing the effectiveness of water management. It does this by adopting a strategy that provides an adequate supply of water to every family.

Fig. 3. Smart monitoring system web interface screenshot

Combining the programming languages of PHP and HTML, the webpage displaying data on water usage, quantity, and supply was created. The webpage automatically refreshes the information after a predetermined amount of time and provides detailed information on water levels, usage, and supply. An Arduino board that gathers data from the water supply sensors is used to compile the information shown on the homepage. The connected device is then used to upload the data collected to the cloud using the Python programming language. This makes it possible to continuously and remotely monitor how much water is being used, ensuring that the supply is properly controlled and used.

5. Conclusion:

Even though water is one of our most basic needs, it must be used responsibly to preserve the environment. It is more important than ever to conserve water resources in order to protect our world. The availability of water sources is significantly impacted by climate change, and an unrestricted supply might result in water waste. As a result, a suggested model is created to ensure the effective use of water and to ensure that everyone has access to enough water.

The suggested model reduces water waste by using Arduino and a number of sensors. The system may collect information on the water level and supply by placing sensors at various places of use. The appropriate amount of water needed by each user is then calculated after the data has been processed and analysed. With this strategy, water is used effectively and wasted water is kept to a minimum.

The suggested model protects the environment while also preserving water resources. We can lessen the environmental effects of water use by using the appropriate amount of water. The suggested model offers a long-term resolution to the problem of water management, guaranteeing that everyone has access to an adequate amount of water without having a harmful effect on the environment.

Even though the suggested approach represents a substantial advancement in effective water management, there is still potential for advancement and additional research. Future research will include using machine learning algorithms to forecast water consumption and find problems with the water supply. This would make it possible for the system to adjust to shifting circumstances and further optimise water usage. Additionally, the system's integration with intelligent irrigation systems for agricultural use may have a big impact on water conservation in that industry.

Future work will also focus on improving the system's user interface to raise user awareness and engagement. This could be accomplished by including real-time data visualisation to assist customers in comprehending their water usage and locating locations where consumption can be decreased. Furthermore, by making it simple for users to access information and alerts about their water supply, developing a mobile application for the system could improve user experience.

The adoption of the technology in further water-scarce areas and nations may have a substantial impact on worldwide efforts to save water. This would necessitate adaption to regional circumstances and laws, but the suggested model offers a solid framework for such growth. Overall, there are a lot of prospects for future research and development employing sensor and IoT technologies in the subject of water management.

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