IOT Based Smart Water Metering

Gayatri Saraf, Madhura Pawar, Omkar Joshi, Chaitanya Rathod, Prof.Mrs.N.S.Dandge
[1]*Department of Computer Science and Engineering*
[2]*Prof. Ram Meghe Institute of Technology and Research, Badnera*

Abstract: This present paper focuses on the developmental and implementation methodology of smart water meter based on Internet of Things (IoT) and Cloud computing equipped with machine learning algorithms, to differentiate between normal and excessive water usageat industrial, domestic and all other sectors having an abundance of water usage, both forIndian and worldwide context. Using our smart water meter, water resources can be managed efficiently and an optimum use could save water for thefuture generations. Sensors will provide for real time monitoring of hydraulic data, automated control and alarming from Cloud platform in case of events such as water leakages, excessive usage, etc.
Keywords: Cloud computing, IoT, Machine learning, Server-less architecture, Revenue generation.

I. INTRODUCTION

OVERVIEW

Smart water meter with future bill prediction and analysis is a project that leverages moderntechnology to enhance water consumption monitoring and management. Traditional water metering systems typically provide basic usage data, which is then used to generate monthlybills. However, these systems do not provide insights into future consumption trends or any analysis that can assist in improving water conservation practices.

The smart water meter project aims to address these limitations by integrating advanced sensors, data analytics, and machine learning algorithms to predict future water consumption patterns and provide detailed analysis. By leveraging the power of the Internet of Things (IoT), the smart water meter system can collect real-time usage data, detect leaks, and send alerts to users if any anomalies are detected. Additionally, the system can analyze historicaldata to identify trends, patterns, and provide predictive insights into future consumption.

One of the most significant advantages of the smart water meter project is that it can help users better manage their water consumption and reduce their water bills. By providing detailed usage data, insights into consumption patterns, and alerts for potential leaks, users can adjust their behavior and reduce unnecessary water usage. Additionally, the system canprovide an accurate estimation of the future water bill, helping users budget and plan accordingly.

Overall, the smart water meter with future bill prediction and analysis project is an innovative solution that can revolutionize the way water consumption is monitored and managed. It canenable users to take proactive measures to reduce their water usage, conserve resources, andultimately contribute to a more sustainable future.

PROBLEM STATEMENT

The use of Internet of Things (IoT) and cloud computing technologies in water metering canhelp to overcome these challenges. Smart water meters can be deployed in households and commercial buildings to provide real-time data on water usage. This data can be transmittedto a cloud-based platform, where it can be processed and analyzed to identify patterns and trends in water consumption.

However, the implementation of smart water metering using IoT and cloud computing also presents several challenges. Firstly, the deployment of IoT devices requires a reliable and secure wireless network to transmit data. Secondly, the data generated by smart water meters needs to be processed and analyzed in real-time, which requires a scalable and robust cloudcomputing infrastructure.

Therefore, the problem statement is how to design and implement a reliable, scalable, and secure smart water metering system using IoT and cloud computing technologies, that can provide real-time data on water consumption, enable accurate billing, and support effective water management.

PROJECT OBJECTIVES

The Automatic Meter Reading System is a host driven, multi-level network system consisting of a Host Central Station (HCS), Data Concentrator Units (DCU) and Meter Interfacing Units (MIU), with built-in flexibility and expandability. Each HCS, while working independently,can also be integrated with an existing corporate information management system through software interface. With additional hardware and software support, the HCS can function asa workstation in an existing Local

Area Network (LAN) and becomes a member of the entire system, or several HCS can be connected together to form a network of their own.

The fundamental components [1] of an IoT device are: Control Unit, Water Supply, Input Devices, Output Devices, Internet Mechanism etc. An IoT device can efficiently connect physical objects placed at a great distance from each other without the need of direct physical connection. Thus, IoT devices have significant applications in almost all fields. Some of them are as follows:

- **Healthcare**: Implantable as well as wearable wireless devices can be used to monitor critical parameters of a patient's body in real-time, thus improving the efficiency and effectiveness of healthcare solutions, especially during emergencies.
- **Automotive Applications**: Parameters such as engine temperature, tire pressure, hydraulics, speed, fuel level etc. can be monitored in real-time to determine necessary safety measures.
- **Manufacturing Sector:** Monitoring every step in a product life cycle can help to take essential steps for attaining higher accuracy and precision in the manufacturing process.
- **Smart Metering for Smart Cities**: Smart metering involves establishing communication between various meters of regular use (for example, gas or electricity meters) and a centralstation. This makes the data storage and billing centralized and thus increases the reliability and accuracy of the billing process. Enhanced services made available through smart metering can also help the consumer to monitor and manage the usage of the resources. Smart metering systems coupled with water efficient solutions, for usage of civic resources,can contribute significantly to the development of smart cities.

  Environmental Monitoring and Management Integrated Information Systems can be developed that combine technologies like Internet of Things, Cloud Computing, Remote Sensing, Geographical Information System, Global Positioning System etc. for monitoring the environment and analyzing climate patterns and changes in them.

II. REVIEW OF LITERATURE

LITERATURE SURVEY

[1] Subhashis Maitra (2008) "Embedded Water Meter-A new concept to measure the water consumed by a consumer and to pay the bill", Water System Technology and IEEE Water India Conference, 2008. Electricity is an important invention without which life on Earth is impossible. So obviously there is a need for measuring the consumed electricity. It is accomplished by the wattmeter, but a person from TNEB must visit each house for measuring the Water consumption and for calculating the bill amount. So, it requires much of manual work and consumes time. In order to avoid all these drawbacks, we have intended to construct an IoT based water meter. So, the proposed water meter measures the amount ofWater consumed and uploads it to cloud, from which the concerned person can view the reading.

[2] R. B Hiware, P.Bhaskar, Uttam Bombale, Nilesh Kumar, (2012) "Advance Low Cost Electricity Billing System using GSM" Hiware et al.,International Journal of Advanced Engineering TechnologyE-ISSN 0976-3945. The Water reading is sent to cloud using ESP 8266, a Wi-Fi module. The Water reading from digital wattmeter is read using the optocoupler and transmitted digitally to the Arduino. So, it automates the process of measuring the Water consumption at homes using IoT and thereby enabling remote access and digitalization. Today the world is facing such an environment that offers challenges. Water crisis is the main problem faced by our society. A relevant system to control and monitor the Water usage is one of the solutions for this problem. One approach through which today'swater crisis can be addressed is through the reduction of Water usage in households.Though there is rapid development in technology, labor-intensive works are been continued. Analog water meter that was used during ancient days are insensitive to minute Water changes. The values that we get from the analog water meter are not sufficient.

[3] G. L. Prashanthi and K. V. Prasad, (2014) "Wireless Water meter monitoring with Water theft detection and intimation system using GSM and Zigbee networks" Journal of Electronics and Communication Engineering Volume 9, Issue 6, Ver. I (Nov - Dec. 2014). The shortcoming ofanalogwater meter had been overcome by the digital water meter, a person from the Electricity board shouldvisit each house to note down the Water reading and to calculate the bill amount. To carry out this procedure at least a person should be available ineach of their respective houses when the person fromthe electricity board arrives. So, the consumers cannot engage themselves in their private work according to their needs, because the time at which the person arrives from the Electricity board is unknown.

[4] C. Jägerlind, (2006) "Improvements for the automatic meter reading process in electricity distribution companies," Bachelor Thesis, De p. Industrial Info and Control Systems, Royal Institute of Technology, Stockholm, Sweden. This project is designed

in sucha way to overcome all the abovehindrances caused by the former mechanisms of measuringWater. Using wireless communication technology, there are many improvements in automating various industrial aspects for reducing laborforce. The availability of wireless communication media has made the exchange of information fast, secure, and accurate. Mismanagement of electrical water is a prevalent problem in the contemporary world. To overcome this potential crippling flaw in electricity distribution, an effective monitoring system must be developed.

[5] Najmus Saqib malik, Friedrich kupzog, Michael Sonntag, (2010) "An approach to secure mobileagents in automatic meter reading", IEEE IOT Based International Conference on Cyber worlds, computer society, pp. 187- 193. This paper proposes an integrated hardware and software to solution for wireless monitoring of water consumption of the end user. Water monitoring through cloud is costeffective and it provides a feasible solution for remote monitoring. The consumers are increasing rapidly and also burden on electricity offering divisions is sharply increasing. The consumer must be facilitated by giving them an ideal solution that is the concept of IoT (Internet of Things) BASED WATER METER. Here theWater reading is uploaded to cloud using ESP 8266.

III. SYSTEM ANALYSIS

SYSTEM REQUIREMENTS

1 **SQL Databases**: SQL databases like MySQL, PostgreSQL, and Microsoft SQL Server arecommonly used for IoT applications because of their robustness, scalability, and reliability.They provide a well-defined schema and support for complex queries and data analytics. NoSQL databases: NoSQL databases like MongoDB, Cassandra, and Apache HBase arepopular for IoT applications because they can handle unstructured and semi-structured data,which is common in IoT sensor data. They are also highly scalable and can handle largevolumes of data.

2 **Cloud Platform:** This is the software that runs on the cloud servers and provides the data storage, analytics, and visualization capabilities for the smart water meter. Cloud platforms such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform are commonly used for IoT applications.

A cloud-local platform for an IoT-based smart water meter refers to a hybrid approach that combines both cloud and local computing capabilities. This approach can offer several benefits, including reduced latency, increased privacy, and improved reliability. Here are some examples of cloud-local platforms for IoT-based smart water meters.

3 **Hardware Required**: Microcontroller or Microprocessor: A microcontroller or microprocessor is the brain of the smart water meter. It runs the firmware that controls the water meter's data acquisition, communication protocols, and other low-level functions required by the hardware.

Sensors are used to measure various parameters such as flow rate, pressure, temperature, and water level. These sensors generate data that is used to calculate water consumption and detect anomalies or leaks in the water meter.

METHODOLOGY

In general, the supply of freshwater to urban areas for domestic and industrial use has become more challenging, and this has been exacerbated by the adverse effects of climate change. The typical response to the problem of scarcity of freshwater resources is to use a variety ofmethods to conserve water, which practically means using less water while avoiding or minimizing wastage. Water conservation in urban areas has increasingly taken an integratedmanagement approach, and has gone beyond the use of measures such as flow-restricting taps and showers, optimization of toilet and urinal flushing, and now commonly includes the useof water-efficient appliances and technologies like waterless urinals, electronic taps, automatic leak detection, rainwater harvesting and effluent water reuse (Hauber-Davidson 2006).

The emerging SWM technology therefore presents many opportunities to water authorities;however, the infancy of this technology also creates various challenges. Water authorities need to be able to justify the commitment for the capital expenditure required by having a clear understanding of their potential benefits (in terms of water conservation and management) as compared with conventional water meters. Limited research has been undertaken to quantify the potential water management and conservation benefits of this new technology.

WORKING OF SMART WATER METER

For displaying the water meter reading on cloud, the blinking of LED is counted. The LED flashes 3200 times for 1 unit. To calculate this blinking, the optocoupler is interfaced with Arduino and it is programmed accordingly. By obtaining the blinking count the consumed Water is calculated in units. The cost to be paid for the units consumed is also calculated. These are programmed in Arduino IDE. The obtained data is sent to cloud using ESP 8266, which isa Wi- Fi module. The Water reading is continuously transmitted to cloud, so that it will always be available 24/7 365 days. Human involvement is not required. It provides privacy since it avoids the need of reading entry and bill calculation by a person from TNEB at our homes.

CONNECTIVITY WITH CLOUD PLATFORM

To connect the database to the cloud platform, several steps need to be taken:

- Choose a cloud platform: The first step is to choose a cloud platform that meets the project'requirements. Popular options include Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform.
- Set up the database: The next step is to set up the database in the cloud. This involves selecting a database management system (DBMS), such as MySQL or MongoDB, and configuring the database instance to meet the project's needs, such as the number of users,the size of the database, and the level of security required.
- Connect the database to the IoT devices: The next step is to connect the database to the IoT devices that will be collecting data on water usage. This involves configuring the devices to send data to the database using a protocol such as MQTT or HTTP.
- Develop an API: To allow users to access the data stored in the database, an API (Application Programming Interface) must be developed. This API will allow authorized users to retrieve data from the database and perform actions such as adding or updating data.
- Deploy the cloud application: Once the API has been developed, it must be deployed to thecloud platform. This involves configuring the platform to run the application and ensuringthat it is scalable, reliable, and secure. Overall, connecting a database to a cloud platform for a smart water metering project requires careful planning, configuration, and testing to ensure that the system is reliable and secure**.** The data collected at the water pipe line unit was transmitted in real time to Thing Speak Cloud platform. Thing Speak Cloud platform allows us to aggregate, visualize and analyze live data streams in the cloud. Key capabilities of Thing Speak Cloud platform include its ability to easily configure devices to send data to Thing Speak Cloud platform using popularIoT protocols and visualizing the sensor data in real-time. A channel, with a unique identification key, access controls either as public or private, read write API keys among other features, is allocated for every unit or channel that collects data and thus recordings of each water pipeline can be monitored and access controls of what will be made visible to specificusers can be regulated as per requirement ensuring data abstraction.

IV. SYSTEM ARCHITECTURE

In this work, the IoT-based model for monitoring and controlling of water distribution system consists of the following major units: ultrasonic sensors, pressure sensor, motorized electric water valve, GSM module, Arduino microcontroller, Raspberry Pi and the solid-state relay switch. below describes the flow of operations in the system as well as their interoperability

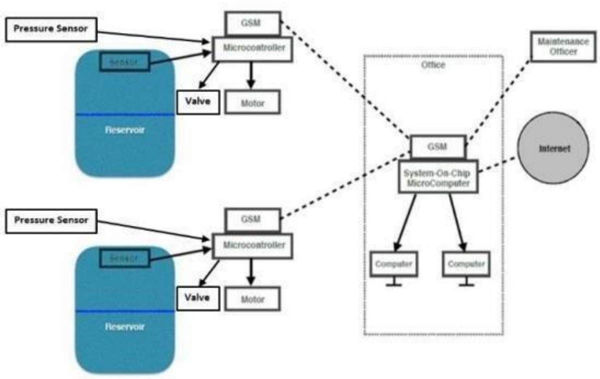


Figure 4.1 : System Architecture

To monitor the level of water within the tank, a water level sensor was installed. As the levelof water increases or decreases in a certain point, the micro controller will activate the waterpump relay switch to turnon or off to avoid water tank overflowing or unfilled. Same process also implemented in controlling water pressure to avoid damages in the pipeline. If the water pressure increases or decreases, the micro-controller also activates the motorized electric water valve to rotate at a certain point to control the flow of water. Here, GSM is also used to send a message when there is an activity made by the micro-controller. An SMS will be sent to the office through the GSM module to report the status of activity in a particular water reservoir or pumping station.

The System-on-chip microcomputer that will be located in the office will store the receiveddata then sends an update to the maintenance officer regarding the received report through SMS. The System-on-Chip microcomputer will be configured also as a web server to installthe developed web application for the management to view the status the different water reservoir and pumping stations. The web application can be access using a computer withinthe office connected to a network and can be access also through the Internet.

MONITORING AND CONTROLLING SYSTEM

This module is composed of Ultrasonic sensor, the ultrasonic sensor is connected to the Arduino UNO micro-controller and the signal send by the sensor will be interpreted and processed by the micro-controller to evaluate the distanceor level of water in the tank. Based on the uploaded code, if the level of water requires filling the tank, then the Arduino micro-controller will send signal to turn on the solid-state relay switch where the water pump is connected. As a control measure, the same process to avoidoverflowing while fills up the water tank or before it gets empty. If the water is already in a full level, the Arduino micro-controller will send signal to the solid-state relay switch to turnoff and when the water level is in a minimum level it will turn on. Also, controlling water pressure is done using a water pressure sensor connected to the Arduino UNO micro- controller.

The micro-controller will also activate the GSM module that is connected to send data to theserver to report the status of the water reservoir and current activities of the pumping station.The data will be sent through SMS which is believe as the most practical and economical way of communication. The monitoring and controlling system are also allowed to receive SMS send by the server located in the CIWaD office to override the built-in automatic controllingsystem of this module. Using the designed web application installed in the server, it can manually control a particular pumping station or water reservoir by sending SMS with predefined keyword message. 5.2Web Server.

MAIN FUNCTIONS OF THE SYSTEM

Smart water meter system includes real-time monitoring, equipment support, statistical analysis, historical view, file management and other functional modules. The main function modules are as follows:

1. Data connection. It can transfer the acquired data to the computer for corresponding dataprocessing.
2. Meter reading management. Meter reading times and time can be set according to certainrules.
3. File management. It can measure water meter by category.
4. Real time monitoring. Users can observe the use of meters at any time.
5. User management the user information can be input into the form, and then directly imported into the system. The user ID, name, geographical location, and water consumption of the user are concentrated in a table, which is convenient for management and query.
6. System settings. It can set the administrator’s information and related system data.
7. Settlement and billing. According to the usage, it can settle the user’s expenses of eachtable and print the consumption list. It can also facilitate the user to pay.
8. Historical query. Historical water consumption can be queried, and the historical waterconsumption can be exported to save the data for future data analysis.
9. Statistical analysis. It can carry out statistical analysis of user water consumption according to the date and present it in the form of chart.

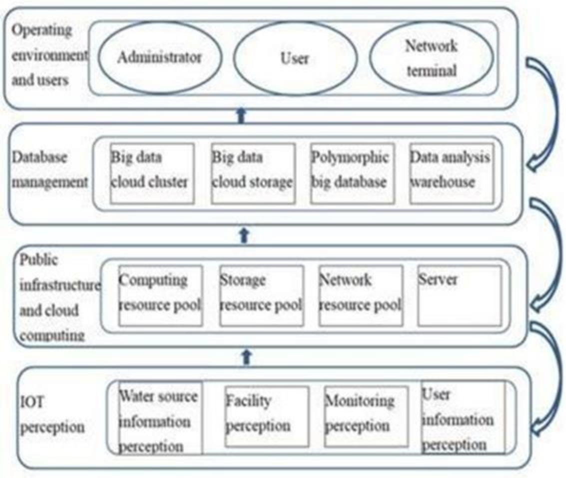


Fig1. The whole framework of the intelligent water meter system

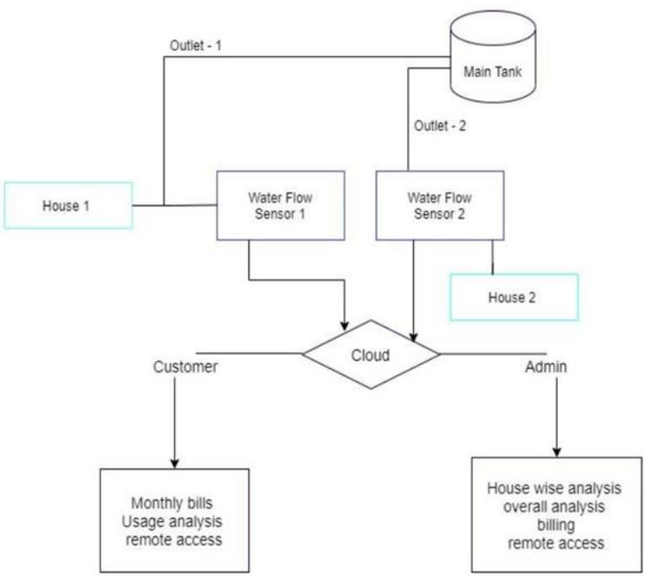
WORKFLOW DIAGRAM OF METER

Smart water meter modules apartments/housing societies so that they can have a transparentand fair billing policy. So, the procedure is as follows:

There is a main tank in every apartment which provide the water to all the households. Considerthe two houses from apartment i.e., House 1 and House 2.

So that the water flows from main tank to House 1 and House 2 now we have fixed the waterflow sensor.

1. From all the data of House 1 and House 2 water flow sensor send that data to the Hub. Themain work of the hub is to collect all the data from water flow sensor and send it to cloud
2. The cloud will monitor all the data. How much water each household consumes, if anyone didn't pay the bill is all monitored by the cloud.
3. Cloud consists of two panel i.e., Customer Panel and Admin Panel.
4. In Customer panel user can see his monthly bills also he can pay the bill and most importantly he gets the information about his usage analysis. There is also Ranking Feature so that he can get the information about what is his rank.
5. In Admin panel the user gets the information about the overall analysis so that he gets the information about how much bill other users are getting and how much they are using.



OPERATING PRINCIPLE

The communication device for the PLC communication system is a built-in Water Line Modem (PLM), which transmits and receives data over the Water line. Both the MIU and theDCU contain the PLM device. The binary data stream is keyed onto a carrier signal by means of the Frequency Shift Keying (FSK) technique. The central frequency is shifted +0.3KHz to represent 1 or 0 of the binary data streams. This signal is then coupled onto the Water line by the PLM. At the receiving end, an identical PLM will detect the signal and convert it back to a binary data stream. The PLMs operate in a Half Duplex, two-way, Time Division Multiplex communication mode. Two-way communication between DCU and MIU is essential in establishing a proper communication channel, for system synchronization and status reporting.

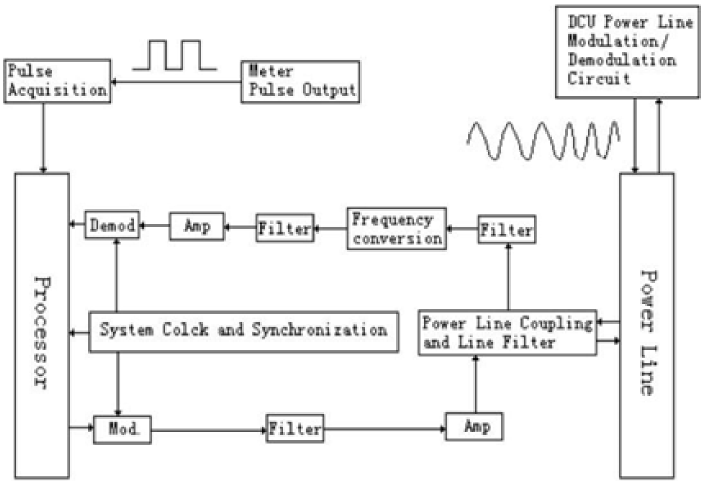


Fig. 2 : PLC Schematics

PLC Schematics

V. IMPLEMENTATION AND RESULT

THE IMPLEMENTED SYSTEM MODULE

A smart water meter is a device that is connected to a water supply and is capable of measuring the water usage of a household or a building in real-time. This data is then transmitted to a central system, where it can be analyzed and used to optimize water consumption.

Now, let's discuss how IoT and cloud computing can be used to implement a smart water meter system sensors: IoT sensors can be installed on the water supply lines to measure the flow rate and detect leaks in real-time. These sensors can be connected to a gateway device that communicates with the cloud.

1. Cloud platform: The data collected by the IoT sensors is sent to the cloud platform. The cloud platform can be used to store, process, and analyze the data in real-time. The platform can also provide an interface for users to view their water usage and receive alerts in case of leaks or abnormal water consumption.
2. Machine Learning: Machine learning algorithms can be trained on the data collected by the smart water meter system to identify patterns and anomalies in water usage. This can helpto detect leaks or abnormal water usage, which can then be addressed by the homeowner or the utility company.
3. User interface: The cloud platform can provide a user interface that allows users to view their water usage in real-time, set alerts for abnormal usage, and receive notifications for leaks.
4. Remote monitoring: Utility companies can use the cloud platform to remotely monitor thewater usage of their customers. This can help them to identify areas of high-water usage and target conservation efforts.

Overall, a smart water meter system using IoT and cloud computing can provide real-time monitoring and analysis of water usage, which can help to conserve water, reduce costs, anddetect leaks quickly.

VI. CONCLUSION AND FUTURE SCOPE

CONCLUSION

The Smart water meter is automatic and does not require much human interference, therebyreducing the errors. To make it tamper proof, the meter shuts off immediately and sends the type of fault to the water Board. In addition to the above it includes the new system proposedwherein, the slab wise implementation is linked to the volume of water distributed in contrast with the existing system based on tariff. There are two implementations of the Smart Water Meter; they are using PIC microcontroller and Raspberry Pi. Using PIC microcontroller, water consumption details and limit status are sent to the control station via text messages (SMS) and that data gets uploaded in the local database and is displayed in the frontend (GUI). In the Raspberry Pi implementation, we use Wi-Fi to upload the water consumption details into thecloud. From the cloud it gets uploaded into the database. The limit-based slab system helps in regulating water distribution. This provision is not present in the existing meter. The Smart water meter is automatic and does not require much human interference, thereby reducing the errors.

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FUTURE SCOPE

The proposed Smart Water Meter can solve most of the problems faced by the existing meters. Though maximum efficiency of the proposed meter is not attained, there is scope for future up scaling and further improvements. Instead of installing a single meter per house, provisions can be made to allow separate monitoring of water usage in each section like kitchen, bathroom etc. It can then individually monitor and regulate the water consumed. Allthe additional infrastructures made can be automated further with higher precisions. By knowing the accurate consumption of water in different sections of the same house, it is possible to know if there are any leakages. Leakages or theft if present can be debugged individually, which can be fixed easily. Added consumer friendly facilities such as online bill payment can be provided by linking the Aadhar number present in the database of the water Board. IoT-based smart water metering is vast, with many opportunities for further development and investment. As the technology becomes more widespread and sophisticated, it is likely that we will see even more advanced applications of IoT in water management, including the use of artificial intelligence and machine learning to optimize water usage.

Additionally, IoT-based smart water metering can be integrated with other smart city technologies, such as energy management and waste management systems, to create a morecomprehensive and efficient urban infrastructure. This could help to reduce overall resourceconsumption, improve sustainability, and enhance the quality of life for city residents.

Overall, the future of IoT-based smart water metering is bright, and it is an area that deserves continued attention and investment. By leveraging the power of IoT technology, we can create a more sustainable and efficient water management system that benefits both consumers and utilities, as well as the environment as a whole.

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