International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Intelligent Wireless Water Monitoring and Management System

S. P. Angelin Claret, A. Jenita Mary, A. Subashini, S. Arun Sahayadhas*

***Abstract:** The need of water in our country has risen hugely to an unprecedented measure. Depletion of available water resources and depreciating the quality of water produces a diversity of trials in managing India's water resources. The result lies largely in areas of effective mechanism for conservation, circulation, competent use and supervision of water. This proposal reports novel trials in the water segment - ease of charges, reasonable charges and the learning of supply versus depletion of water to generate alertness in order to limit the use of excess water and to assist preservation. Shortcomings of the surviving prototypes demand for the pervasive procedure of a wirelessly monitored 6LoWPAN based smart water metering and management system. We intended to do this with the assistance of TI's CC2538 modules programmed using ContikiOS, to accomplish the task of actuation and monitoring over CoAP in the application layer. Sensor data is communicated wirelessly to a gateway, such that the data is made available online through the internet.*

***Keywords—** cc2538,Contiki, 6LoWPAN,Water,Wireless*

I. INTRODUCTION

Water scarcity is a common problem in India. As a country that receives copious rain, studies indicate that water scarcity can be attributed mostly to human factors. Wasteful usage by people is a leading cause for the inadequacy. While rapid population growth, increasing population density and climate change continue to exacerbate the problem, there is a demand for monetary need of water. In India, physical investigation of water metersis carried out for charging reasons, a method that is vulnerable to human mistakes and operations. It requires residents to be present at home in order to provide access to the meters. Also, several houses in a building use a shared water meter. For the conservation of water a small amount of incentives are provided evenly regardless of the distinct usage. The smart water metering systems that are wireless sensor networks are used to measure the sporadic in valid period over a wireless network to central database.

Manuscript published on 30 September 2019
* Correspondence Author
Dr.S.P.Angelin Claret*, Assistant Professor in the Department of Computer Science in SRM University, Chennai.
Subashini, S., Assistant Professor in SRM Institute of Science and Technology in Chennai.
A.Jenita Mary MCA.,M.Phil, Assistant Professor working at SRM Institute of Science & Technology.
Dr. Arun Sahayadhas, Professor with the Department of Computer Science and Engineering in Vels University, Chennai.

To measure this, the water meters are installed in numerous houses. The timely caution can be updated by the smart metering system for the uncommon occurrence of continuous water drift. The intervention strategy and to reduce the excessive wastage of water this smart metering aids are an excellent assistance for the water providers [1].At present when related with the wired devices, the wireless ones are less price and easy to execute. The contiki OS is an Open source operating system. This operating system supports for the low power wireless IOT for network and memory constrained systems [2].

To exploit the routing protocol with 6LoWPAN header compression and adaptation layer for IEEE 802.15.4 links for low-power and lossy networks (RPL) the IPv6 stack in contiki is implemented [3]. The IPv6 protocol is compacted but leads major portion for payload [3]. By this method, the usage of data is very less and thus provides minimum power. The 6LoWPAN also removes the implementation of TCP and instead uses the UDP protocol at the transport layer which is unreliable and connectionless [3]. The application layer controls the occurrence of errors by delaying the transmission whenever it is suitable. These characteristics of 6LoWPAN make it ideal for power constrained devices in a wireless sensor network. It can be considered as a revolution in the sense that it will provide global connectivity even to the smallest embedded devices each of which are assigned IPv6 addresses.

The appropriate application layer protocol resides above the IP network layer based on demand. The HTTP is one of the predominate application layer protocol in the internet. But this HTTP is not fit for constrained networks. The constrained REST full Environments working group developed the constrained application protocol (CoAP) as a lightweight alternative for HTTP. To provide power efficiency the IETF constrianed application protocol influenced ContikiMAC lower power duty cycling mechanism [4].

Even though wireless technology is being tested out elsewhere for smart billing it becomes equally important to develop a system that lets the users monitor and control the supply of water in their house. The smart water monitoring and management system employing the above mentioned concepts can tackle issues that require consideration in India. However preserved water is provided by water boards, the streched distance and leakage of water can cause the water to foul. The quality of water is actually a foremost concern, we propose, to measure various parameters such as pH, ORP, etc. for the supplied water to every firm and raise a notification to residents if they do not lie within permissible limits.

The smart water monitoring and management system will provide a detailed report regarding water consumption patterns based on hall-effect flow sensor outputs, which will assist as a warning to the citizens about the surplus use of water in their individual firms. This will stimulate the civilians to protect the water to reduce their water bills, particularly; water paucity is likely to raise prices. The smart water monitoring and management system proposes to serve as an alternative to the existing system, thereby overcoming its drawbacks.

A.Proposed Solution

The proposed wireless system allows the users to observe the usage and the quality of water as shown in Fig.1. The cc2538 motes acting as end devices are lined with pH, ORP and flow sensors transmit the values wirelessly to a cc2538 mote acting as the border router.It is connected to the BeagleBone Black which acts as the gateway connecting this network to an Ethernet network and potentially beyond. The individual motes having their own IPv6 addresses can be retrieved, supervised and measured from distant positions using CoAP.

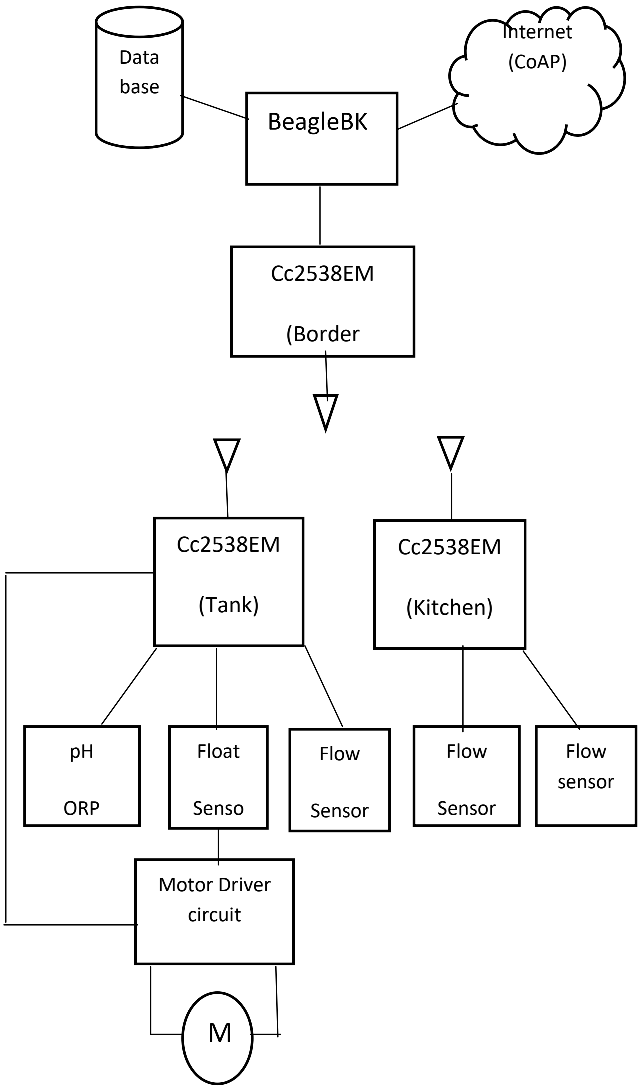

Fig.1. The Proposed Architecure

B. Technical Background

Wireless technology is currently being used in a few places to make billing easier. But the system has to evolve further to ensure greater human participation. We propose a WSN system based on TI's cc2538, to provide users the access to individual wireless nodes using their IPv6 addresses and hence allowing them to monitor usage patterns at different outlets. In addition to providing a transparent and fair billing method, our system also allows users to monitor water quality as contamination is possible in the distribution and storage systems.

II. CASE STUDY OF EXISTING SYSTEMS

The water quality smart sensors are used in the smart water quality monitoring system. The sensor that transmits the data to the device can assemble data from every node in a wireless form. This data can be given to the remote server through GPRS network. The user can view the data distantly. Fiona Regan, Antoin and Audrey designed that, this system is faster, greatly mountable and user friendly. Due to smart sensors used this system is costlier and the sizes of the sensors used are not consistent for water tap [5]. To eliminate the cost expending jobs of maual moinitoring Nazleeni et al.,developed a water quality monitoring system[6]. This system determines the data processing unit through GSM modem by the computed data evaluated by the water quality sensors. The data processing unit are used to differentiate the data from various sensors and regularly balanced with the ultimate limit of the sensor value. The alert signal is attached to the buzzer which ensures that the water has not met its limit value. This system supports only individual unit of water source and not for long distances. Ann developed a monitoring system for water quality [7]. In this system the data are evaluated by the information collected from industrial water and municipal water storage. The informations are processed in the substation by the water quality sensors. This progressed information are updated to the main station through Ethernet networks running on TCP/IP. From here, the data is separated and is updated to the environment and public department using internet. This system produces reliablity, efficiency, data accuracy, effective data management and fully integrated information systems. This system cannot provide real time monitoring for various parameters of water. The solar powered water quality monitoring system with wireless sensor network was developed by Kulkarni Amruta and Turkane Satish [8]. This system uses the WSN technology in the solar panel. It entails nodes and base station. This node fetches the information from various wireless sensors and it is connected to the base station by Zigbee technology. It will enable only when the solar panel get charged, otherwise the system will stop its functioning. This method utilizes a very less cost. The above methodologies produce some constraints in the regular monitoring of water quality parameters. All these limitations in the existing systems have led us to develop and design the new methodology that will be low-cost, real-time and user friendly.

Tomas et al [9] developed architecture for examining the activities of business under various implementation levels using decision support system. This architecture consists of various boundaries and levels to activate the interaction between the layers.To monitor the eminence of water in an accurate time some sensors with eminent parameters are used by patawala [10]. Laxmi et al [11] proposed an IoT based method to overcome the water deficit by continuous monitoring of the delayed flow of water distribution by the producers.

To provide sufficient and quality water to all the houses and industries with good forces a raspberry Pi monitoring method is used. This method stores the data in the cloud for regular updations. Thereby the information can be processed by any persons at any regions [12].

III. PROPOSED SOLUTION

The proposed system aims at improving the current standards of water billing and monitoring in India. Smart refers to exact volume of water flow using electronic components, wireless communication with the data center, automated billing and tamper proof metering. The GUI is a Silverlight Application designed using Microsoft Visual Studio Express 2013 for web. It provides interaction with the user, statistical analysis on water usage, tariff calculation and billing. The solution of the paper aims to educate people with detailed analysis of their water consumption patterns.

IV. IMPLEMENTATION

A.Hardware Implementation

The paper uses TI's cc2538 wireless microcontroller SOC. The device combines a powerful ARM Cortex-M3-based MCU system with up to 32KB on-chip RAM and up to 512KB on-chip flash with a robust IEEE 802.15.4 radio. This module was ideal for our design that required wireless solutions running the IPv6/6LoWPAN stack. The 12-bit ADC with 8 channels provides us a wide scope to interface a large number of sensors to a single board.

B. BeagleBone Black

Here we are using TI's BeagleBone Black as a gateway to connect the 6LoWPAN based wireless sensor network with an Ethernet network. The 1GHz AM3359 Sitara ARM Cortex-A8 processor was ideal for us to run Ubuntu 14.04 LTS on the BeagleBone Black. One of the cc2538 motes acting as the border router is lined through the USB 2.0 port of the Beagle, which in turn acts as an midway device to provide renovations between 6LoWPAN and standard IP headers. The virtual network interfaced with Serial Line Internet Protocol (SLIP) causes IP traffic to and from border router above a serial line. Thus the wireless sensor network can communicate with the Ethernet network and potentially beyond, allowing users to access and control the motes from any remote location.

C. Water Flow Measuring module

The water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. The rotor rolls when water flows through it. Its velocity varies with dissimilar amounts of flow. The hall-effect sensor outputs the corresponding pulse signal. External interrupt is enabled on the cc2538 mote to detect the pulse signal in order to evaluate the amount of drift and hence the corresponding capacity of water disbursed at the outlet.

D. Water Float Switch

The float sensor contain a hermetical sealed reed switch in the stem and a permanent magnet in the float. By the rising up or going down levels of liquid, the reed switch is enabled by the magnet. The signal that is enabled in the float sensor produces the motor to push the water from the underground to overhead tank automatically.

E. L293D IC

TI's L293D motor driver IC is used to provide a highly accurate control of the motor. The IC controls the motor to pump water in the prototype. The enable pin on the IC is connected to the CC2538 mote to give the user the power of actuation using CoAP.

F. TPS61220EVM

TI's TPS61220EVM is used to obtain a regulated power supply from batteries for the pH and ORP sensors.

G. pH / ORP sensors

Fig. 2. pH/ORP sensors

Phidget's pH and ORP sensors are connected to the ADC pins of the cc2538 mote as shown in Fig.2. These sensors are used to ensure that the quality of water being supplied to the house is within permissible limits.

H. Software Implementation

This section deals with the different aspects of smart water monitoring and management system that are programmed. Two important software code are used for the border router that is connected to the BeagleBone Black and for the end nodes running CoAP.

Table-I: Layers and its Protocols

Layer	Protocol
Application	CoAP
Transport	UDP
Network	IPv6/RPL
Adaption	6LowPAN
MAC	CSMA
Radio duty cycling	ContikiMac
Physical	IEEE 802.15.4
Protocol Stack	

I. Processing Flow Sensor Output Flowchart

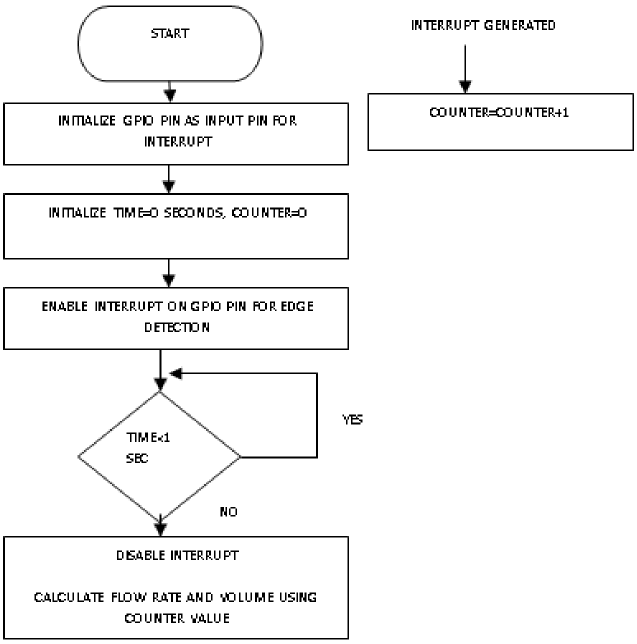

Fig. 3. Processing Flow Sensor Output Flow chart

J. Flowchart for processing pH/ORP sensor output

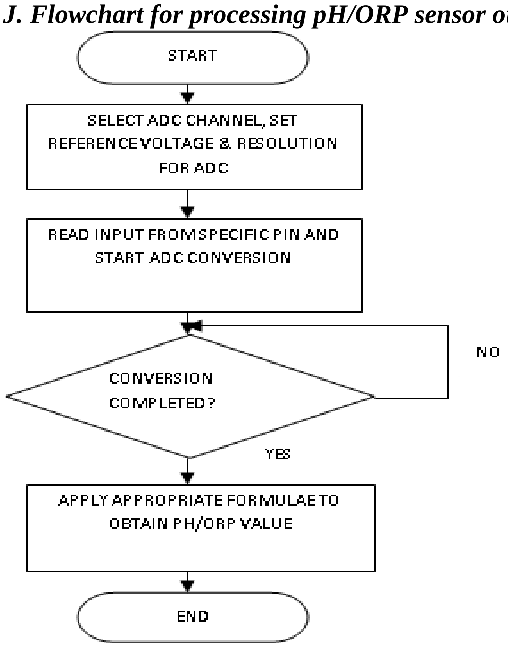

Fig.4. Flowchart for processing pH/ORP sensor output

The functionality of the border router can be summarized as follows.

The border-router are identified in the border of a network.It provides the direction to send the data between the WSN (RPL network) and external IP network.

1. The border-router connects two networks (here RPL network and Ethernet network) by utilizing the tunslip utility.
2. The tunslip utility creates a virtual network interface over the serial line connecting the border router with the gateway.
3. To set the prefix the border-router has to wait to receive the prefix through SLIP from the BeagleBone Black.
4. Once the border-router receives the prefix it is set as the root and it sets the prefix for other nodes in the network.
5. The end nodes form a DAG (directed acyclic graph) with the border-router as the root node.
6. The OSPF (Open Shortest Path First) routing algorithm is applied in the border-router which is based on link state algorithm (LSA) to establish connections or routes with its neighbors.
7. It computes shortest path for each route using the Dijkstra's algorithm.
8. Border-router uses NUD (neighbor unreachability detection) and BFD (Bidirectional forward detection) to check the state of connection to the neighbor (whether connection is 'Incomplete', 'Delayed', 'Unreachable').
9. The border-router hosts a webpage. The webpage can be viewed by typing the IPv6 address of the border-router in the address-bar of a web browser.
10. The webpage mainly displays the IPv6 addresses of the neighbors and shows the routes through which the end nodes form a connection with the router.
11. These IPv6 addresses of the end nodes are used to access the CoAP webpage where parameters are monitored and actuations can be carried out.

Table-II: The Average and Efficiency of water levels

Expected Value(mL)	Actual value (mL)			Average (mL)	Efficiency (%)
	I	II	III		
100	88	93	102	94	94
200	200	188	190	193	96.5
300	303	296	289	296	98.65
400	397	404	391	397	99
500	498	507	501	502	99.6
600	602	611	595	602	99.6
700	702	710	712	708	98

The resource macros are defined by the resources used and for the estimation and evaluation of sensor values End node use CoAP at the application layer to interconnect over the internet. It is designed to easily translate to HTTP to make web access easy. CoAP is mainly designed for low power WSN nodes.

V. RESULTS

The table below shows the efficiency of our flow sensor for flow rates below 4L/min. For higher flow rates a flow meter with a bigger nozzle can be used.

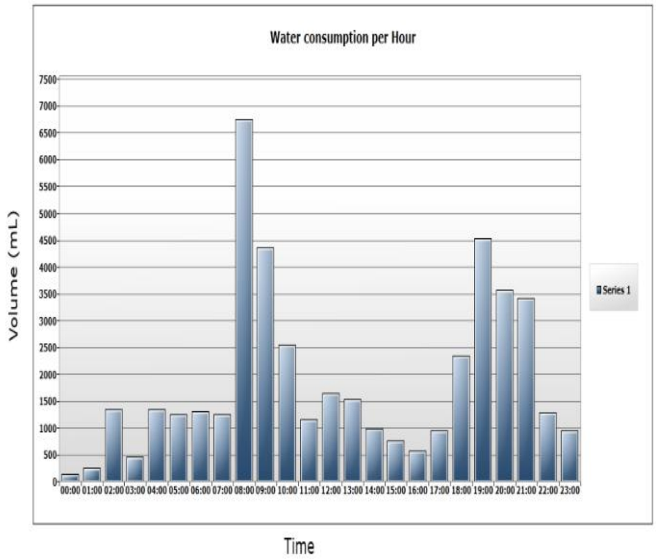

Fig.5. The water consumption for 1 hour

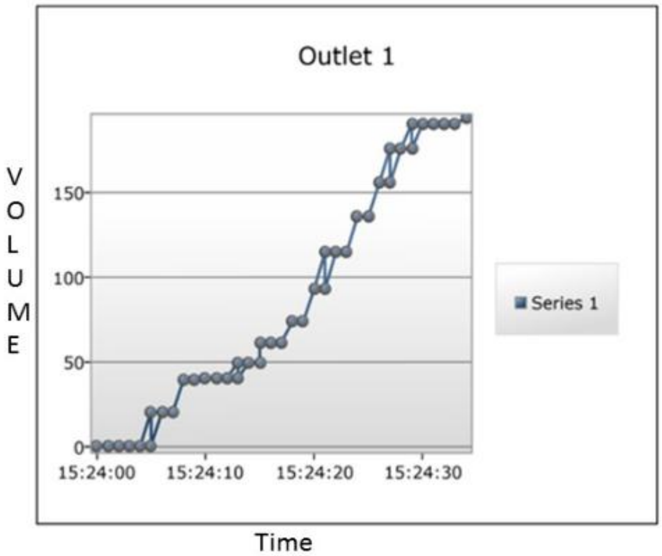

Fig.6. Overall efficiency – 97.90 %

Graph below shows the amount of water consumed at outlets 1 and 2. These graphs can give statistics of water consumption .Electronic bill can be sent to users, which is accessible by both the user and the water supply board.

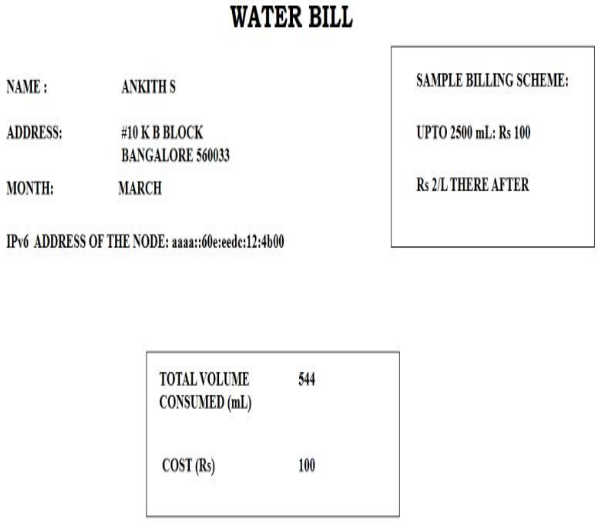

Fig.7. Water Bill for Total volume consumed

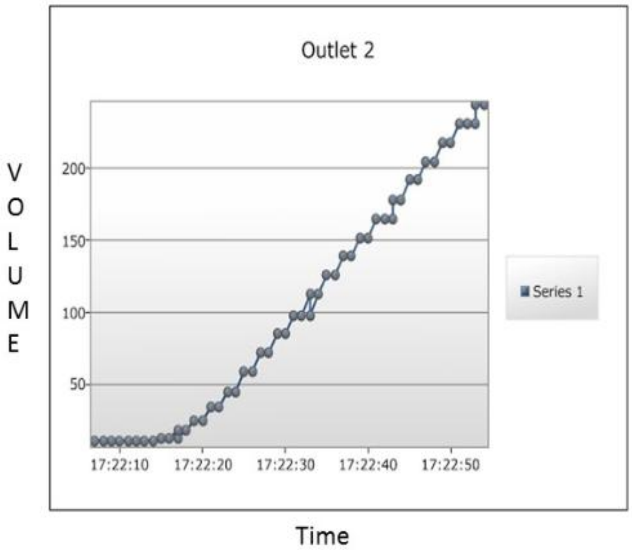

Fig.8. Efficiency rate for outlet 2

The following pie chart can be used to compare water consumption at each outlet.

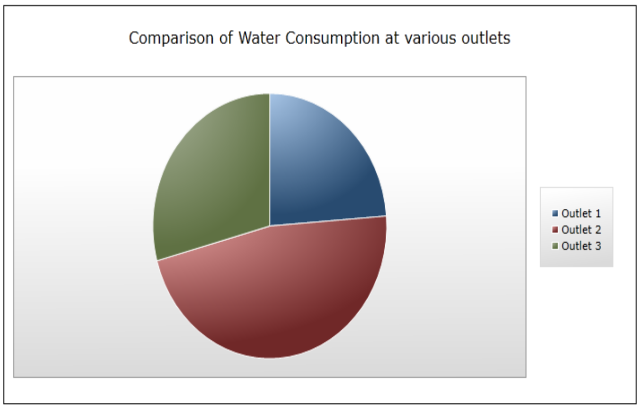

Fig. 9.Comparison of water consumption at various outlets

VI. CONCLUSION

In this paper, we presented an internet of things based approach to monitor and control water usage. The prototype implementation was carried out using an IPv6 enabled Wireless Sensor Network (6LoWPAN) utilizing the emerging HTTP-compatible Constrained Application Protocol for both monitoring and control of the system. Users are provided with information on their water consumption patterns and hence can be persuaded to cut down on unnecessary usage. Water quality can be monitored. The water metering system is digitized and automated high accuracy is maintained by decreasing human effort. Several houses in a building can have different end nodes, but a common gateway and hence billing can be based on their individual consumption instead of dividing the total bill amount equally. Water theft can be evaded as there are no mechanical parts that can be tampered with and also the user can use real time monitoring to be aware of water being stolen at any outlet. Our prototype can be augmented with other sensors for industrial and real field deployment to demonstrate the usefulness of the approach. The existing water monitoring systems includes certain drawbacks such as it cannot provide real time monitoring of water parameters, it is unreliable for long distance, it will apply only to a single unit of water source and it is also very costly due to use of smart sensors. All these limitations in the existing systems has led us to develop and design the new methodology that will be low-cost, real-time and user friendly. Notifications for leakage detection along the pipes could be a future enhancement.

REFERENCES

1. 1.Rachell Cardell-Oliver, “Discovering water use activities for smart metering”, Intelligent Sensors, Sensor Networks and Information Processing,IEEE, Melbourne, VIC, Australia. 2013.
2. 2.Adam D., Bjorn G & Thiemo V, “Contiki - a Lightweight and Flexible Operating System for Tiny Networked Sensors”,Local computer Networks,IEEE, Tampa, FL, USA, USA. 2004.
3. 3.Xin M & Wei L, “The analysis of 6LoWPAN technology”. IEEE Pacific Asia Workshop on Computational Intelligence and Industrial Application, Wuhan, China. 2008.
4. 4.Matthias K., Simon D & Adam D, “A Low Power CoAP for Contiki”, Mobile Adhoc and Sensor Systems,IEEE, Valencia, Spain. 2011.
5. Fiona R., Antoin L & Audrey M, “SmartCoast Project -Smart Water Quality Monitoring System, Environmental Protection Agency”,IEEE, Local Computer Networks. 2009.
6. 6.Nazleeni S.H., Mohd K.B., Izzatdin A.A & Mazlina M, “A System Architecture for Water Quality Monitoring System Using Wired Sensors”. Information Technology,IEEE, Kuala Lumpur, Malaysia. 2008.
7. Ning & AN Yu, “A Monitoring System For Water Quality”, IEEE International Conference on Electrical and Control Engineering, Wuhan, China ,4615-4617, 2010.
8. 8.Kulkarni A.M & Turkane S.M, “Solar Powered Water Quality Monitoring system using wireless Sensor Network”, Automation, Computing, Communication, Control and Compressed Sensing,IEEE, Kottayam, India. 2013.
9. Tomas R., Ramon A & Diego M, “An IoT based reference architecture for smart water management Processes”, Journal of Wireless Mobile Networks. Ubiquitous Computing, and Dependable Applications, 6(1), 4-23. 2015.
10. Patawala A.H., Bansode N.P., Bhong Y.P & Zadbuke A.S, “IOT Based Water Management System for Smart City”, International Journal of Advanced Research,Ideas and Innovations in Technology,3(2),379-383. 2017.
11. Laxmi P & Laxmi G.D, ‘Smart Water Management Process Architecture With Iot Based Reference’, International Journal of Computer Science and Mobile Computing.6(6), 271-276. 2017.
12. Joy S, “An Internet of Things Based Model for Smart Water Distribution with Quality Monitoring”, International Journal of Innovative Research in Science, Engineering and Technology, 6(3),3446-3451. 2017.

AUTHOR’S PROFILE

Dr.S.P.Angelin Claret is an Assistant Professor in the Department of Computer Science in SRM University, Chennai. She pursued her doctorate degree from Bharathiar University, Coimbatore. She has published many articles related to component based power distribution system. Her research interests are component based technology, power distribution system, Internet of things, Machine learning. E-Mail:angelins@srmist.edu.in

A.Jenita Mary MCA.,M.Phil currently as an Assistant Professor working at SRM Institute of Science & Technology. I received bachelor’s degree from the Computer science Department,J.A.College, MK University, Madurai, in 2000, MCA degree from MGR arts-science college ,Periyar University, Salem in 2003,M.Phil degree from Periyar University, Salem in 2008.I have Twelve years of experience in teaching field and very much interested in big data analytics especially machine learning which is my research area.
E-Mail:jenitaa@srmist.edu.in

I received my M.Tech., degree from SRM University and M.Phil., degree from Bharathidasan Universtiy in Tamil Nadu. I am currently working as an Assistant Professor in SRM Institute of Science and Technology in Chennai. My research interests are in Machine Learning, Deep Learning, Data Mining and Internet of Things. I have published eight papers in journals and international refereed conferences. Now I am doing PhD(Computer Science) in SRM Institute of Science and Technology in Chennai.E-Mail:subashia@srmist.edu.in

Dr. Arun Sahayadhas is Professor with the Department of Computer Science and Engineering in Vels University, Chennai. He also serves as the Director of Internal Quality Assurance Cell at the University and thereby enables quality culture. He has his doctorate degree from University Malaysia Perlis also known as UniMAP in Perlis, Malaysia. He has setup an Artificial Intelligence Lab in Vels and works towards continual innovation. His research interests are in Transportation safety, Human Computer Interaction, Artificial Intelligence, Bio signal processing, Image processing and Behavior analysis.
E-Mail: arun.se@velsuniv.ac.in