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Smart Device to monitor water quality to avoid pollution in IoT environment

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***Abstract*— Internet of Things (IoT) is a global network of "smart devices" that can sense and interact with their environment using the internet for their communication and interaction with users and other systems. The main concept behind every IoT technology and implementation is "Devices are integrated with the virtual world of internet and interact with it by tracking, sensing and monitoring objects and their environment". The features of a "smart device" that can act as a member of IoT network are, collect and transmit data, actuate devices based on triggers and receive information(from network or internet). Currently in our country, the water analysis is done manually by taking the samples from the water sources (lake) and sent to the lab (TWAD) for investigation. To automate this process, water quality monitoring sensors, arduino IDE, Zigbee module and data concentrator module are physically placed in each and every water sources (lake). The water quality monitoring sensors gather data from water, and forward that data to Arduino IDE for binary to digital conversion. The arduino IDE forward that data to concentrator module through Zigbee module for remote transfer of data to the lab. The data concentrator which is located in each and every lake, send that data to the cloud configured server which is located in the TWAD testing laboratory. The TWAD department employees monitor this data remotely and securely provide this data to the requested users which is stored in the cloud. Water quality parameter data is stored in the cloud, will be securely provided to requested users using the cryptographic techniques.**

Index Terms*— Internet of Things (IoT), Remote Monitoring, Cryptography

I. Introduction

Internet of Things (IoT) is an integrated part of future internet and could be defined as a dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'things' have identities, physical attributes and virtual personalities and use intelligent interfaces which are seamlessly integrated into the information network. In the IoT, 'things' are expected to become active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information 'sensed' about the environment, while reacting autonomously to the 'real/physical world' events and influencing it by running processes that trigger actions and create services with or without direct human intervention. Interfaces in the form of services facilitate interactions with these 'smart things' over the Internet, query and change their state and any information associated with them, taking into account security and privacy issues.

The water quality monitoring is the essential need for the human life. There are huge numbers of diseases which cause through the polluted drinking water. The water will be polluted by the human being, animals, natural disasters and seasonal changes. So, people have to aware of their own locality water bodies conditions. To enable this, a prototype is proposed to monitor water quality in IoT environment.

II. RELATED WORK

Water quality monitoring can be used to protect source waters by identifying pollutant levels and locations in a source water. Water quality monitoring is commonly done multiple times a year because water quality may change with season and with weather events. Water quality can be monitored by measuring physical, chemical, or biological characteristics of the water. Shruti Sridharan et al. [1] addressed in their project about developing an efficient wireless sensor network (WSN) based water quality monitoring system, that examines water quality, an important factor as far as, irrigation, domestic purposes, industries, etc are concerned. R.Karthik Kumar et al. [2] investigated Underwater wireless sensor network to monitor the quality of water using wireless sensor network (WSN) technology powered by solar panel. Through WSN various data collected by various sensors at the node side such as pH, Turbidity and oxygen level are sent to base station. At the base station collected data is displayed as visual and is analyzed using different simulation tools. Marco Zennaro, Athanasios Floros, Gokhan Dogan, Tao Sun, Zhichao Cao, Chen Huang, Manzoor Bahader, Herve' Ntareme et al. . [3] proposed the design of a water quality monitoring system and, building upon the SunSPOT technology, a prototype implementation of a water quality wireless sensor network(WQWSN) as a solution to the water quality monitoring problem. Daudi S. Simbeye and Shi Feng Yang [4] provided the design of water quality monitoring and control system for aquaculture based on wireless sensor networks and single chip computer technology as a base in the actual operation. It realizes the monitoring of the water environmental parameters for intensive aquaculture and alarm notification through short message when monitored variables take anomalous values and is suitable for long-term stability under growth conditions thus increasing yield per unit area.

Kirankumar G.Sutar, Prof.Ramesh T.Patil [5] presented the fish farm monitoring system based on wireless sensor network. The system is constituted by a base station and sensor nodes. The sensed parameters with their exact precision values are transmitted to the observing station through wireless communication and details are monitored by the administrator. When any of the parameter is found to be above a threshold value an indicator will indicate it. The system has advantages such as low power consumption, more flexible to deploy. A.C.Khetre, Prof.S.G.Hate [6] investigated and defined a wireless sensor network for water environment monitoring system. It provides a useful feature's such as large monitoring ranges, low cost, low power consumption, flexible configuration and very small damage to the natural environment. The system successfully provides on-line auto monitoring of the temperature, turbidity, water level, and salinity. Zhu Wang Qi Wang, Xiaoqiang Hao [7] discussed the problem of the manual analytical method adopted in water quality detection with bad real-time character and introduced a novel kind of remote water quality measuring and monitoring system based on WSN.

Zulhani Rasin and Mohd Rizal Abdullah [8] proposed implementation of high power Zigbee based WSN for water quality monitoring system with low power consumption and high reliability presented. The use of high power WSN is suitable for activities in industries involving large area monitoring such as manufacturing, constructing, mining. Geethanjali.S, Mekala.M,Deepik [9] presented a narrative water eminence monitoring organization Zigbee based on wireless sensor network contributing small power utilization with high reliability. Peng jiang and Hongbo xia [10] have proposed the Design of water environment system based on wireless sensor network. This system takes MSP430F1611 main processor to develop automatic water environment monitoring system.

O'Flynn,B,Martinez-Catala [11] have developed automated water environment monitoring system using GSM technology, this system sends the online measurement of water parameters directly on mobile phone through GSM technology. Mingfie Zhang, Daolaing Li [12] presents a system framework taking the advantages of the WSN for the real-time monitoring on the water quality . They design the structure of the wireless sensor network to collect and continuously transmit data to the monitoring software then accomplish the configuration model in the software that enhances the reuse and facility of the monitoring project. This monitoring system has been realization of the digital, intelligent, and effectively ensures the quality of aquaculture water.

In the proposed system, IoT environment for remote monitoring and secured data access for sharing with cloud setup is used to address the issue of human intervention.

III. PROPOSED APPROACH

Water Quality Monitoring System Design

Currently in our country, the water analysis is done manually by taking the samples from the lake and sent to the lab for investigation. The proposed work reduces human intervention by using IoT and is presented in Figure 1. The shell consists arduino micro controller, sensors arranged in bread board and Zigbee module. The arduino microcontroller is connected to the data concentrator using USB cable. The arduino microcontroller sends the water quality parameter's data which is read from the sensors to the concentrator through Zigbee module. The data concentrator which is located in each and every lake, send that data to the cloud configured server which is located in the TWAD testing laboratory. The TWAD department employees monitor this data remotely and securely provide this data to the requested users which is stored in the cloud. After the water quality parameter data is stored in the cloud, it will be securely provided to request users using the cryptographic techniques.

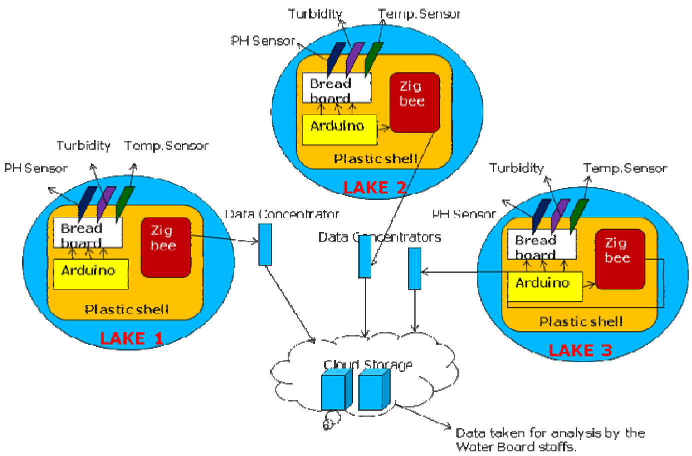


Figure 1: System Design

Obviously, the physical work of TWAD employees physically go to each and every lake and water bodies will be avoided and thus human intervention is reduced.

Zigbee Module

ZigBee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. ZigBee is based on an IEEE 802.15.4. Though its low power consumption limits transmission distances to 10–100 meters.

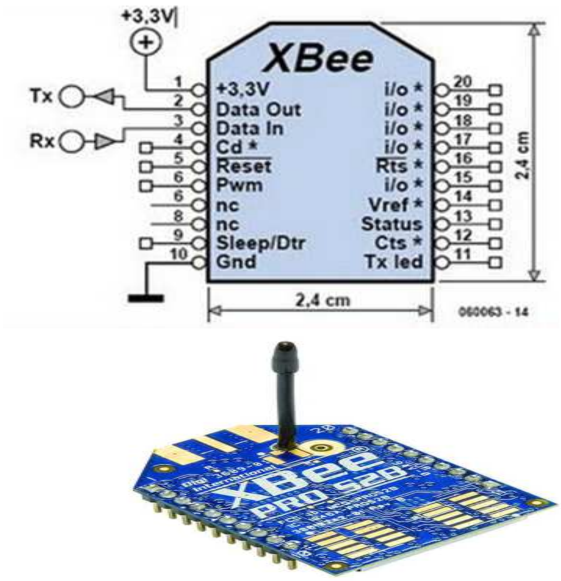


Figure 2. Zigbee module pin diagram

Data Concentrator

A data concentrator is a software and hardware solution that connects a number of data channels with one destination. Data concentrators are found within substations to help managing many different data sources at one main source.

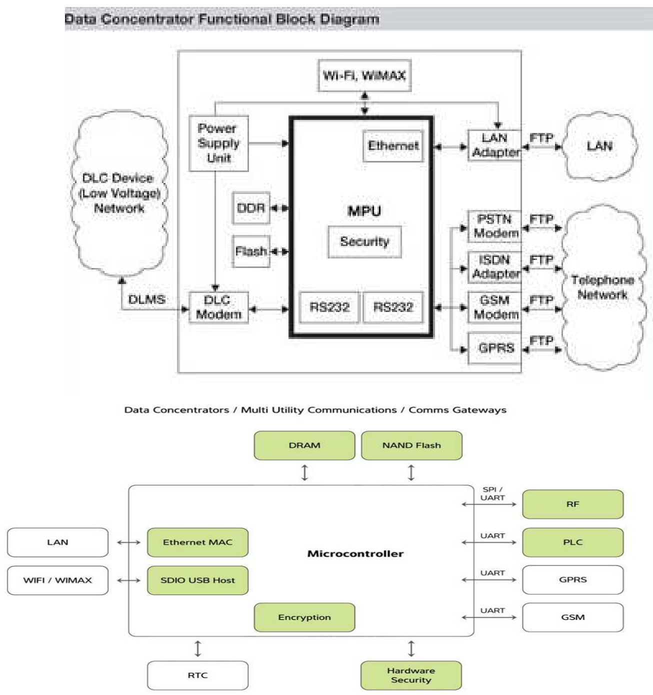


Figure 3. Data concentrator block diagram

The Data Concentrator which is used to receive data from different types of network and also do the work of transfering the data to the destination.

IV PROTOTYPE IMPLEMENTATION

The PH sensor, Temperature and Turbidity sensors are used for monitoring water quality and are connected to arduino board for gathering water parameters. The arduino board will gather the data from sensors and convert that data into digital form and send that data to the cloud enabled system for securely providing the data to the public users and analysis. In this manner many water sensors could be deployed and the data collected will be stored in the cloud storage from which further analysis will be made.

The analysis will be carried out for pollution due to changes in water parameters because of,

- Climate (Rain, Temperature, Environment, Dust) change
- Population
- Industrial wastage.

Arduino can sense the environment by receiving input from a different sensor (temperature, PH, Turbidity) and send the data to cloud enabled system. The microcontrollers on the board is programmed using arduino programming language based on wiring and arduino development based on processing.

The Arduino Integrated Development Environment (IDE) is a cross platform application written in java and derived from the IDE for the processing programming language and wiring projects. A program or code written for arduino is called as “sketch”. Arduino Board with Temperature Sensor – Wiring Diagram is given in Figure 4. Sensor Vcc output pin is connected to the input of Arduino Board 5.0 V. Sensor Data output Pin is connected to the input of Arduino Board Digital Pin of 3. (0-13 Pins). Sensor Gnd output Pin is connected to the input of Arduino Board Gnd.

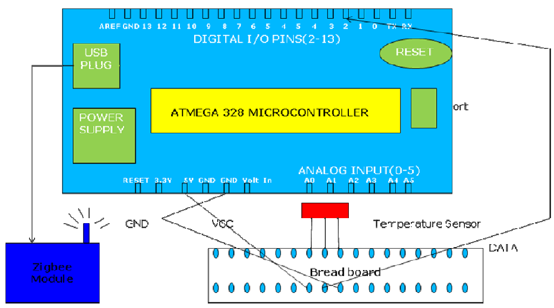


Figure 4. Wiring Diagram

The Zigbee module in turn used for remote transfer of data from Zigbee module (Lake) to data concentrator module which is located in the Water Testing Laboratory of TWAD board.

Algorithm for monitoring Temperature (Sample Sensor)

Procedure TempMonitor

Input: pin numbers
Output: Temperature (celcious) digital values
Settings: Menu Bar → Tools → Set Board Type as Arduino Uno
Menu Bar → Tools → Set Serial Port as COM 20.

```
begin
  while(1)
        Read the water temperature value with delay
        of 10 sec
         Log this data to text file.
         if (temperature > threshold value) then
         send temperature value to the system
         else
         don't send temperature value to the system
       end if
   end while
end
```

"Arduino sketch" which is written in the Laptop is uploaded to arduino board with the help of USB cable. One end of USB cable is connected to arduino board and another is connected to Laptop/PC. Sensor has three pins namely, ground, $v_{cc,}$ and signal. Ground, $v_{cc,}$ pins are connected in bread board whereas signal pins represent the pin in the arduino board. From arduino board (5V pin, Gnd Pin, 3-digital pin) connected to water Temperature sensor (v_{cc} pin, Gnd Pin, Data pin) through Bread board. If the temperature goes beyond or below the threshold limit (written in the arduino sketch), the arduino board send the report to cloud enabled system.

The temperature sensor sense the data and send that data to arduino board with the help of signal pins connected to arduino pin numbers (Digital pin – 3). This data acts as input to arduino microcontroller. The data is processed with the arduino coding and the output is send to the cloud enabled system.

The RSA cryptosystem is used for secured sharing.

RSA Algorithm

Key Generation Algorithm

Step 1: Generate two large random primes, p and q.

Step 2: Compute n = p*q and z = (p-1)(q-1).

Step 3: Choose a number relatively prime to z and call it d.

Step 4: Find e such that e*d=1 mod z.

Step 5: The public key is (n, e) and the private key is (n, d).

Encryption

Sender A does the following:-

Step 1: Obtains the recipient B's public key (n, e).

Step 2: Represents the plaintext message as a positive integer m.

Step 3: Computes the cipher text c =m^e mod n.

Step 4: Sends the cipher text c to B.

Decryption

Recipient B does the following:-

Step 1: Uses his private key (n, d) to compute m = c^d mod n.

Step 2: Extracts the plaintext from the integer representative m.

V.RESULTS AND DISCUSSION

Testing Environment Setup

The prototype is tested in the environment shown in Figure 5.

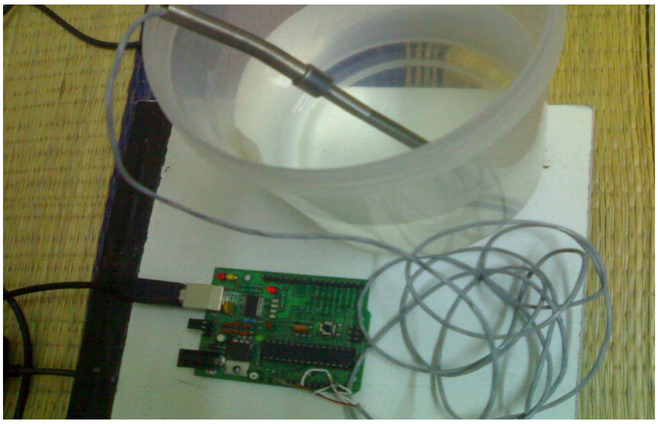


Figure 5. Testing Environment Setup

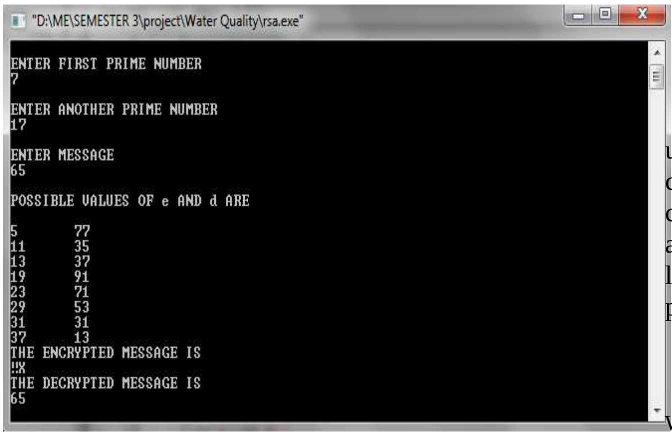
The temperature reading of water using sensors through arduino board is done in "Internet of Things" Environment.

Water Temperature is : 18^{O}C" Water Temperature is Normal"
Water Temperature is : 25^{O}C " Water Temperature is Normal"
Water Temperature is : 28^{O}C " Water Temperature is Normal"
Water Temperature is : 30^{O}C " Water Temperature is Normal"
Water Temperature is : 35^{O}C " Water Temperature is High"
Water Temperature is : 35^{O}C " Water Temperature is High"
Water Temperature is : 65^{O}C " Water Temperature is High"

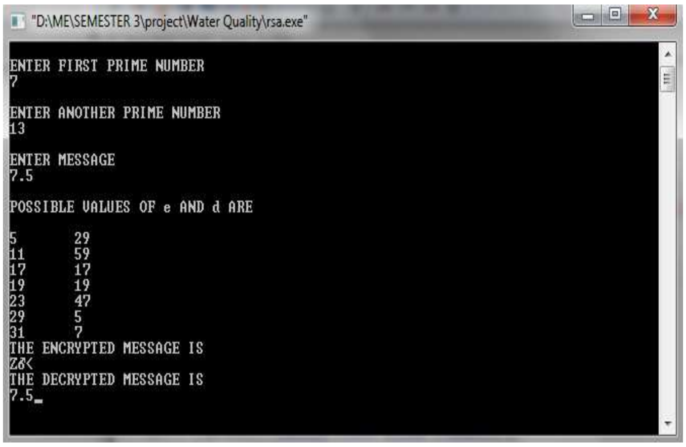
Figure 6. Results obtained from Arduino Board

The sensed parameters available in the cloud system is shared by RSA algorithm and the screen shots of the sample tested results are given in Figure 7.

RSA Input: Temperature



RSA Input: pH



RSA Input: Turbidity

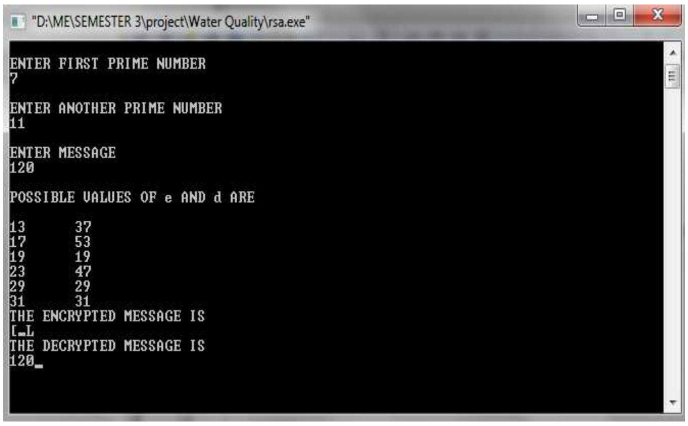


Figure 7. Results obtained for secured data access

But some disadvantages are felt in the security of the system due to complexity of the key creation. Hence variations in the RSA algorithm used is required.

So, to manage the security in the cloud we need to extend this algorithm to another one, which have more secured data sharing to the cloud users.

FUTURE WORK

This water quality monitoring work can be extended. By using the water quality parameter data, reason for pollution can be analyzed. In this analysis, the prediction of the condition of the water can be justified by using the mining algorithms. One can tell the water conditions of the specific locations based on the historical data of the water quality parameter data collected in the cloud.

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