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PANI: Pure Water Analysis using Near Field Communication and Internet of Things

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Abstract

India is suffering from one of the world's worst national water crises. With a population of about 1.3 billion, water as a basic need is increasingly becoming scarce across many regions in India. Residential consumers remain the largest portion of water users. The most essential requirement to ensure good quality water availability is to conduct regular testing of water. In the proposed system, various water quality parameters such as pH, turbidity, TDS, and temperature are monitored in real-time. Any deviation from the standard values points towards the presence of pollutants and hence is unfit for consumption. In addition to that, this system aims to bring down the consumption by certain liters per day and charge the users according to their consumption rates. This will make profligate users more aware of their consumption. In the proposed model, a system is designed for a smart water quality and management system by monitoring the water quality & consumption in real-time and pay using NFC technology, and cloud-based data analytics as per their consumption.

Keywords— *Water Quality Parameters, Internet of Things, Cloud-based data analytics, Near Field Communication Technology, Cryptographic Algorithms and Cloud Wallet.*

I. INTRODUCTION

India is considered the center of the global water and sanitation crisis. With more than 2/3rd of total fresh water being contaminated, India is not even in the top 100 countries in the water quality index. The WHO estimated, in India among 77 million people are suffering due to not having safe water where 21% of diseases are related to unsafe water. To ensure healthy water fit for consumption, various water health parameters should be monitored and regulated. The traditional water quality monitoring methods involve the manual collection of water samples from distinct places. These samples are tested within the laboratory using rigorous skills. Such methods are time-consuming and aren't efficient. In our proposed model, various water health parameters such as pH, turbidity, TDS, and temperature are monitored regularly and necessary actions are taken.

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Residential consumers remain the largest portion of water users. However, there is a supply gap in the chain of water where an average quantity of water supplied by urban local bodies in India is 69.25 liters per person per day whereas the required quantity of water to be made available in the cities is 135 liters per person per day. A WWF-India report projects that 30 Indian cities will face a 'grave water risk' by 2050 due to a sharp increase in population. So, to quench the thirst of this supply-demand chain crisis, another important factor to be considered is to avoid the reckless consumption of water. Most families' wastewater roughly every day whether it is due to leaks or utter negligence. And since the consumers pay a standard charge for water in a residential or commercial society, those who are careful consumers take the burden of these profligate users on their shoulders. Hence there is a need for sustainable and smart water supply management practices to build a water-secure future. In our proposed model, we create a system to check the rate of water utilized per individual family and charge them based on their consumption. If the family goes way past the set values, the users are notified of their increased consumption rates, thus helping them identify the consumption inefficiencies, and hence build a water-secure future.

Payment for their consumption can be done using Near Field Communication (NFC) with either an online wallet or tokenized coin secured by cryptographic algorithms. The mobile wallet is assumed to be managed by Mobile Network Operator as described in [5]. Our proposed model uses the already existing security features to achieve authentication and integrity for offline transactions using an NFC mobile Phone.

II. LITERATURE SURVEY

Reference [1] focuses on the importance of WQM applications and ensures that it employs low transmission power communication for disseminating data. For a healthy water supply chain, water health parameters are essential for water management personnel. Contaminated water leads to the transmission of chronic diseases like cholera, diarrhoea, dysentery, etc.

Reference [2] shows real-time water quality monitoring using Wireless Sensor Network. An Internet of thing (IoT) based water quality monitoring system is proposed to detect various water parameters. This proposed system consists of a collection of sensors to monitor various water parameters such as water temperature, carbon dioxide (CO2), pH, turbidity and water level. The collected data is computed using VHDL and C language. The computed data is transmitted through the Zigbee module. The water parameters are measured in the base station which is also accessible on the Grafana dashboard. This system cannot be used at commercial places as only a single user can access the water quality parameter through their PC.

Reference [3] shows how the IoT technology can be used in real-time water monitoring systems as water is a crucial part of our everyday life. An IoT-enabled water monitoring system is proposed for true time water level detection. In the proposed system, HCSR-04 is used to calculate the distance between itself and the water level of the tank. The data transmission of the sensor is done by a wireless gateway within the consumer network. A cloud server is deployed to store the data forwarded by the gateway. When the water level crosses the Not Safe Level and Danger Level accordingly the LED and Buzzer are triggered to alert the consumer about the water flow.

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Reference [4] has proposed a cost-effective framework for water supply. It is regularly supervised and controlled from the central server to eliminate water theft issues. [4] The proposed system aims to tackle the water management related issues such as water overflow, overutilization and distribution, thus diminishing human work and time. This model utilizes an Arduino UNO, YF-S201 sensor, and solenoid valves as main hardware, and an IoT based Blynk application to turn on the valves.

Reference [5] shows that cloud computing controlled by Mobile Network Operator (MNO) can be used to hold customer's banking credentials, whereas the Secure Element (SE) present in the NFC Mobile is used for customer authentication.

An NFC payment model has been proposed in [6] which is based on [5] for a definitive NFC ecosystem to do online transactions. Every transaction that occurs is verified by the MNO and Secure Element (SE) is used for user authentication. The model that has been proposed in [5],[6] does not mention anything with regards to offline transactions. To keep the private key offline, a hardware token is used for completing transactions as described in [7], but still, the POS is required to have an active internet connection. All the previous transactions are verified to make sure that the transactions were confirmed by the bitcoin network.

III. EXISTING WORK

For better designing of a system that enables efficient use of water, it is important to understand the needs of consumers and how they are responding to the availability of water. The water management system in India is not uniform and does not always adhere to the water guidelines issued by the WHO. Even though municipal water systems treat the water before pumping it to the users, the water has to travel a long distance via pipelines that are buried under roads and sidewalks to reach its desired location. This can challenge the purity of water and give way too many water-borne diseases like Cholera, Typhoid, etc if consumed. The existing system measures water level, water temperature, CO2S, turbidity, and pH, but fails to measure the dissolved impurities. This methodology of manual testing has disadvantages like a complicated system, long waiting time for results, low measurement precision, and high cost.

In addition to the quality of water, another important water crisis is the regular monitoring of water consumed per household. Households being one of the biggest consumers of water, there is no regular monitoring of water consumed which leads to reckless consumption of freshwater. Most families waste roughly 35-40 % of the water every day – whether it is because of accidental leakages or utter negligence. Water mains are maintained by the local governments and paid for by water rates and property taxes. Since the consumers pay a standard charge for water in a residential or commercial society, those who are careful consumers take the burden of these profligate users on their shoulders.

There is no transparency in the system. The consumers hardly know how safe the water is and what their consumption rate is.
For making a transaction it is necessary to be connected to the internet and the money is centralized, i.e., controlled by a financial institution, whereas in crypto-currency the system is completely decentralized. It is hard to keep a track of a person's assets for taxation and even crypto-currency transactions require a

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momentary connection to do the payment. In a crypto block, all the transaction history is stored in the transaction details. The basic blockchain structure is displayed in Fig. 1.

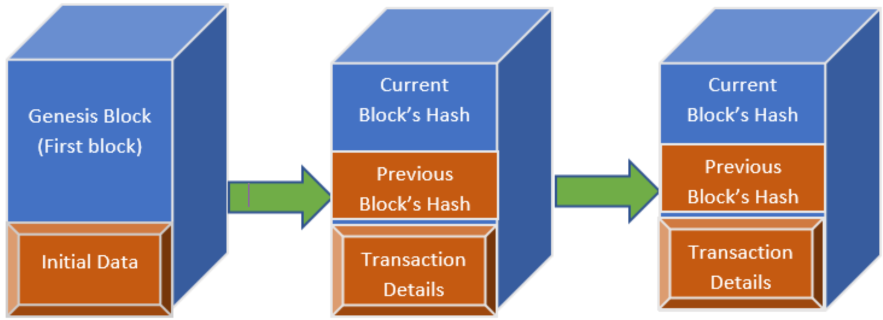

Fig. 1 Basic Blockchain representation

IV. PROPOSED SYSTEM

Our proposed model understands the water needs of every household by regularly monitoring their water quality and consumption rate. The water quality parameters such as pH, turbidity, temperature, and TDS are monitored at a regular interval using suitable wireless sensors. This real-time monitoring of water quality is used to alert the users to current, ongoing, and emerging problems; that determine compliance with drinking water standards and protect other beneficial uses of water. If there is any deviation from the standard WHO-certified values, the IoT system is trained to notify the users and alert them to take the necessary actions.

The rate of consumption of water is monitored by using a Hall Effect sensor. According to the consumption, the rate of water utilized will be set to every individual family. If the family goes way past the set values, the users are notified of their increased consumption rates, thus helping them identify the consumption inefficiencies.

Our project also offers a way to do the payment in offline mode using cryptographic algorithms which are not limited to this project. The transactions done using cards can expose profuse personal information and can also be accessed without permission. A system is proposed that uses cryptographic encryption to create a secure virtual debit card. The coin is associated with a token having limited time to live (TTL) during which it is transferable from one NFC-enabled device to another. Internet connection is required for combining the coin with a token. It can be added to the cloud wallet[1] after all the successful transactions. After a coin's TTL has expired, it can no longer participate in transactions but can be added to the cloud wallet[1] and then again is usable with another token.

V. METHODOLOGY

A. WATER QUALITY DATA

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The water quality measured using sensors is uploaded to the cloud using Arduino and ESP-01S Wi-Fi module. If data accumulated by any of the sensors are outside the safe values set by WHO the users will be notified that the water is unsafe and the Tank should be cleaned. TCP/IP protocol is used to upload the data to the cloud.

B. WATER CONSUMPTION DATA:

The water consumed by the user is uploaded to the cloud using Node-MCU. It uses the MQTT protocol to upload data to the cloud.

C. USER ACCESS TO DATA

The user login through the PANI application through their ID and password. To see the water quality data, the user has to select the “Water Quality Parameters” button and will see the “Water Health Parameter” UI as shown in Fig. 2, and to see the quantity of water used by then they have to select “My Consumption” and will see the “Water Consumption Data” UI as shown in Fig. 3. The user data is fetched using HTTP protocol and is in JSON format.

D. NFC ONLINE PAYMENT

When in the “Water consumption data” screen, the user can select the show bill and proceed to pay using an online transaction and the transaction history will be stored on the cloud.

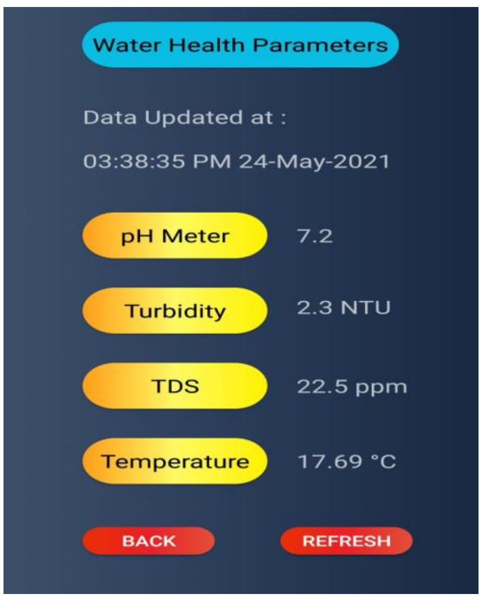

Fig. 2 UI Screen of Water Health Parameter

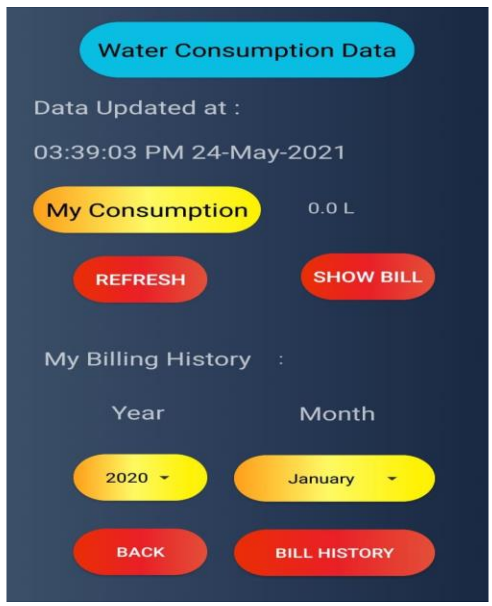

Fig. 3 UI Screen of Water Consumption Data

E. NFC OFFLINE PAYMENT

If the user wants to pay in offline mode or send money to another user, they have to select offline mode and download tokens before they can proceed with payment. To make the process secure the maximum time for which the tokenized coin can be used should be kept as minimum as possible. The user can use the tokenized currency till the TTL doesn’t become less than the minimum required value for a successful transaction.

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VI. ALGORITHM

For a transaction to be successful in online mode, the receiver is required to have an active internet connection. This kind of transaction fails in case of momentary disconnection or if either the receiver or the sender's payment server is down.

For a transaction to be successful in offline mode i.e., both sender and receiver are offline, the tokens should not expire during the transaction. Hence the token which has TTL greater than or equal to a set value *x* can only be used for the transaction.

Proposed Algorithm for Offline Transaction using NFC:

1. Sender applies for combining coin & token via internet
2. sender receives token with TTL via Internet access
3. while TTL >= *x* and Transaction is offline
4.   hand-shake between sender & Receiver
5.   receiver sends the amount of data
6.   sender receives the data and asks for amount confirmation
7.   receiver confirms amount
8.   sender sends the current embedded with active tokens
9.   receiver checks the value and TTL on token
10.   receiver removes any duplicate of the sent token from the sender's account
11.   the transaction details are added in the token
12.   receiver confirms, sends receipt, and terminate the transaction
13. end
14. Receiver connects to a cloud wallet to convert tokenized coin into wallet currency

The above algorithm can be modified for a mixed-mode of transactions in which either one (sender/receiver) is online or the other is offline.

VII. FLOW CHART

The initial connection is set up between the sensors, Arduino board & wifi module with the cloud. The sensors read the data and send it to Arduino which uses the Esp wifi module's connectivity to upload it to the cloud. The uploaded data is checked for safe limits set by WHO, if the data is outside the safe range a notification is sent to users for tank cleaning. After this process, the Arduino goes into Idle mode for power saving. The flow chart for this is shown in Fig. 4.

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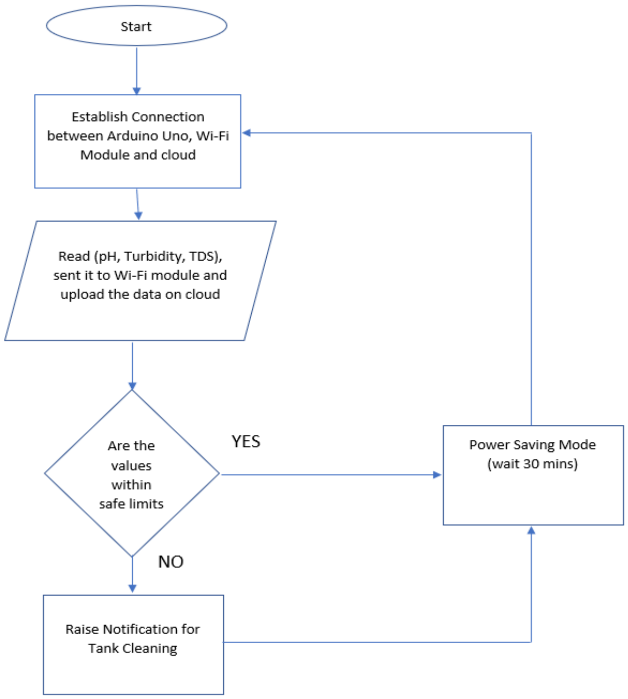

Fig. 4 Represents the Flowchart for water Quality Measurement

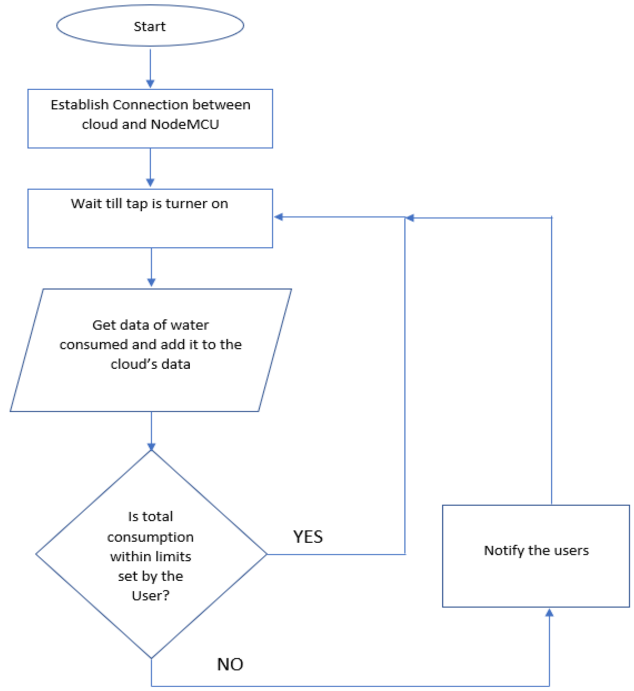

Fig. 5 Represents the Flowchart for water Consumption per family

The initial connection is set up between the NodeMCU board and the cloud. The data calculation is on hold till the tap isn't turned on. As soon as the tap turn on the volume of water used will be calculated using flow formulas of the Waterflow sensor. When the tap is turned off the data is uploaded to the cloud and the total consumption is checked. If the consumption crosses the approx. consumption limit set by the user, they'll be notified. The flow chart for this is shown in Fig. 5.

VIII. HARDWARE TESTING

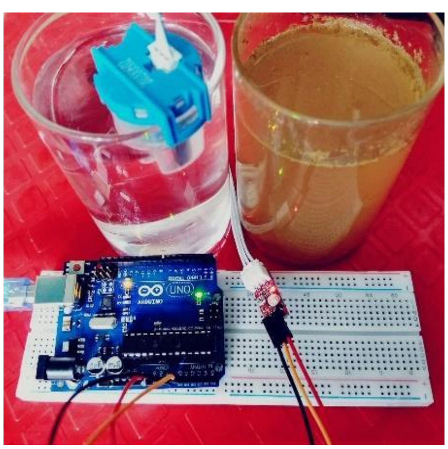

Fig. 6 Hardware Connection of Turbidity Sensor with Arduino Uno

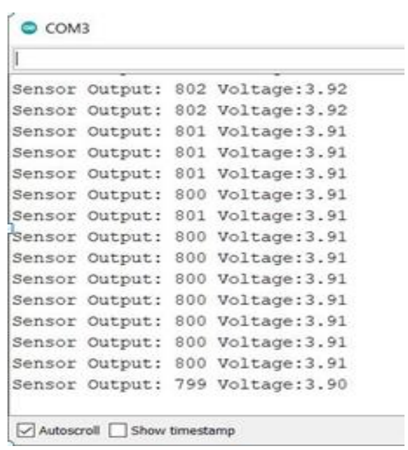

Fig. 7 Tap water Simulation result

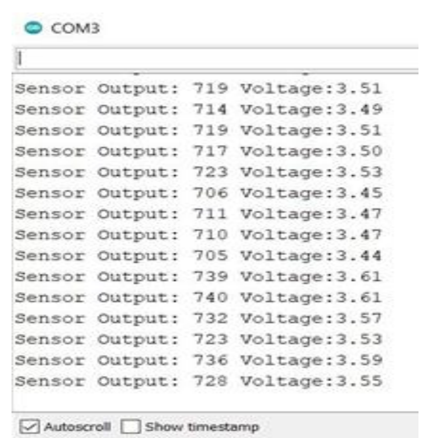

Fig. 8 Mud water Simulation result

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The simulation result shows that more impure water will decrease the data received by turbidity sensor which in turn reduces the voltage as shown in Fig. 7 and Fig. 8.

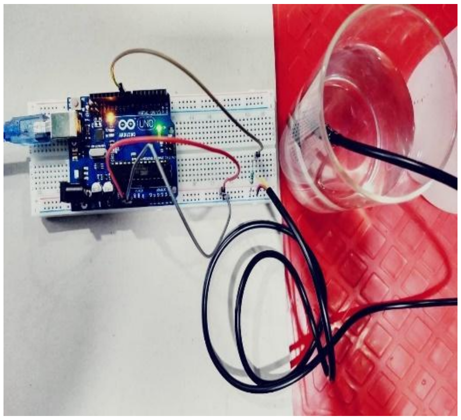

Fig. 9 Hardware Connection of Temperature Sensor

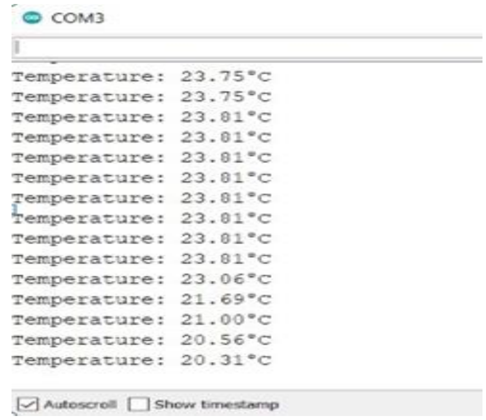

Fig. 10 Simulation result of temperature sensor

The temperature sensor is simulated by mixing cold water in water kept at room temperature as shown in Fig. 10.

IX. Conclusions

Clean water is essential to the public's health. In this paper, we propose a model which makes sure that the users get clean and safe water for their use. Using IoT data analytics, the users are notified if the water isn't clean so that they can take the required action. For ensuring sustainable use of water, the consumption of every household is measured and saved on the cloud in our proposed model. The users are charged for the water they use, shielding them from the burden to pay for water used by the profligate users.

For every transaction, an active internet connection is needed, but there are certain blind spots with no connectivity. Those situations require an offline transaction. We have proposed an NFC payment model using encryption techniques of crypto-currency and secure mobile money for payments in such scenarios. The encryption technique combined with TTL makes sure the mobile money is safe from unauthorized access.

X. Acknowledgment

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