Blockchain and IoT for Auto Leak Unearthing

Pooja Sapra, Vaishali Kalra, and Simran Sejwal

Abstract Blockchain and Internet of Things (IoT) are important constituents of Internet-enabled era of information technology. Both technologies are distributed, autonomous, and decentralized systems. IoT devices require the strengthening of its security features, and security is an intrinsic aspect of blockchain due to cryptographic mechanisms. On the other hand, blockchain needs contribution from the distributed nodes and IoT includes within its architecture. So, blockchain can aid in the settlement of major security requirements in IoT. Blockchain features such as decentralization, immutability and transparency (DIT), auditability, and data encryption help to solve various IoT architectural problems. The main goal of water supply sector is to provide a solution to get shielded, authentic, and cost-effective water supply through well-regulated arrangements. It is very hard to achieve these goals. This paper introduces an algorithm for implementing a smart water management system that identifies and quantifies the water requirement by an individual consumer within a given locus and also identifies leaks (if any) in the plumbing system. The system proposed monitors both water quality and water scarcity aspects within the supplied vicinity. The smart water management system is collateral to a decentralized system implemented using smart tanks that uses the Internet of Things (IoT) for implementation and blockchain technology for providing a more rooted mechanism.

Keywords Blockchain · Internet of Things · Water management · Security

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1 Introduction

The significance of the Internet of things has progressed on account of the mix of different advancements, real-time analytics, AI, ware sensors, and embedded systems. Internet of Things has been a blessing across each domain of modus and numerous business ventures, and some of the emerging fields in which IoT is largely used includes client engagement platforms, optimization of technology, waste reduction, enabling smart homes, elderly care, transportation, buildings and home automation, infrastructure application, health care, and many more. A major drawback of IoT in terms of water management is dispensing a sense of security within the system that has been lacking in the traditional methods for the same. This void can be replenished using the advantages of blockchain technology.

In a perfect world, water resource management planning has regard to all the contending requests for water and tries to designate water on an impartial premise to fulfill all uses and requests [1]. Probably the greatest worry for our water-based assets later on is the manageability of the current and future water asset allocation. As water turns out to be rarer, the significance of how it is overseen develops vastly. Finding a harmony between what is required by people and what is required in the earth is a significant advance in the maintainability of water assets. Non-revenue water (NRW) real losses include leaks and bursts from the underground pipeline network. About 20% of the water produced is simply wasted because of underground water leakage which goes undetected, and some old or worn-out pipes might end up wasting 50% of water in supply [2]. Most leaks remain unidentified being underground. Water leakage detection program identifies and reports leakage problem and reduce previously undetected leaks.

The system is required because leakage in pipes lead to:

- Health issues of people due to contaminated groundwater.
- Ineffective supply management.
- Ineffective demand management.
- Weakening of the physical infrastructure.
- Customer dissatisfaction due to unreliable service of poor quality.

This system is explicit, anchored, ensures to an extent that the condition of water scarcity does not arise and also encourages individuals to conserve water along with earning some reward. Also, the proposed system utilizes sophisticated methodologies of the buzzing technology—Internet of Things (IoT) [3, 4], blockchain, and smart contracts for implementing such systems [5].

Blockchain Technology: A chain of blocks, having information about each transaction, is called blockchain. Each block has the address of its previous block that makes data provenance easy and difficult to tamper. Further, if data received from IoT sensors is placed in blockchain, it would reduce the possible attacks of leakage.

Smart Contracts: Smart contracts are the logical piece of codes, recorded in the blockchain and are triggered when an event takes place. Ethereum virtual machine

(EVM) is deployed to avoid the hacking of the smart contracts. There are many languages and IDEs available to develop the smart contracts like serpent, solidity, Go, etc. In this paper, we have considered solidity language to develop the smart contracts on Remix IDE. Smart contracts are deployed using Ganache tool.

2 Literature Survey

Various methods have been considered and implemented toward providing a secure management plan, and in this section, we would discuss the related work toward a secure water management plan.

Author in [6] proposed a system that takes into account the acoustic emission techniques to identify leak in the pipeline. This method uses acoustic (sound) sensors which work on the phenomena of sound propagation and uses sound waves to detect leakage. Sound waves would travel back and forth in a pipe with a certain wavelength, and the wavelength noted on a leakage would differ from the original ones, and hence, the leakage is detected.

The proposed system has a few drawbacks associates to it which includes: (i) Relying on the concept of sound propagation might not be accurate enough to detect the exact location of the leak. (ii) Acoustic sensors do not yield accurate results which might cause errors or failure in detection.

Authors in [7–9] incorporated methods that uses global system for mobile communication (GSM) to monitor leaks. Once the leak is identified, GSM technology is used to deliver an alerting message to the users designated mobile. Major disadvantage of this method is that GSM technology only allows producing an altering system and does not cater to provide the exact location of the leak within the plumbing system. Some other orthodox methods for management and for detection of leakage are using water sensors. This mechanism is very feeble and of low precision as (i) Water sensor would fail to identify leakage in underground pipes, (ii) Water sensor would detect minor leakages or underground water, (iii) The degree of accuracy decreases drastically. Such methods would be beneficial at small scale such as home automation or finding minor faults in the water supply.

Author in [4] caters to the issue in a sophisticated format using GSM technology for altering system on leakage, liquid crystal display (LCD) to remotely monitor inflow and outflow rate of water and flow sensors to determine the mass flow rate of inflow and outflow of water used in the pipelines. The system lacks a sense of security that could be provided taking into account the advancements in blockchain and cloud computing as blockchain has been seen as a cut above the traditional ways to secure our IoT devices.

The software-based solution for water management is provided in [1], wherein the author installed the smart water meters, and based on the data collected from the meter, the predictions are made using AI forecasting techniques. Based on the obtained predicted data, the meta-heuristics algorithms have been applied for smart management of non-renewable resource water. This one technique would also help

in reducing the pumping activity. In order to save the water usage, the author [10] brings an android-based solution for small to medium size garden that measure the soil moisture level, air condition, and humidity level using sensors and schedule the watering of the plants. The proposed framework is built on fuzzy rules and introduced block chains to provide access to trusted devices only. In 2018, IBM [11] also proposed a blockchain model with IoT integration to establish clarity in the use of water in the asymmetry industry and to illustrate its importance in sustainable water management. This blockchain solution also help in providing the transparent trading of water contracts which further saved our resources [12]. This blockchain with IoT implementation is also proposed for creating the future smart cities [13, 14].

3 Proposed System

Water being a non-renewable resource is critical for human sustainability, and proper methods are to be incorporated to ensure more longevity and better management for future needs; hence, a fool proof method is required for water management, and detection of underground leaks to eradicate the issues that are associated with it. In our proposed system, we have tried to eradicate some of the issues related to the same, which includes the following:

- Hydrostatic pressure sensors as they are more accurate sensors as compared to existing models
- Using GPS technology allows fetching the exact geographical location of the leak
- Introducing blockchain to secure the system
- Chances of error or failure decrease drastically
- Higher accuracy and exact location detection
- The proposed system can function underground as well.

The work flow of the proposed model given in Fig. 1:

i. **Connection and Establishment of Smart Tanks**: For identification of leaks, the proposed model will include implementation of a smart tank, using hydrostatic pressure sensor and pH level indicator for water quantity and

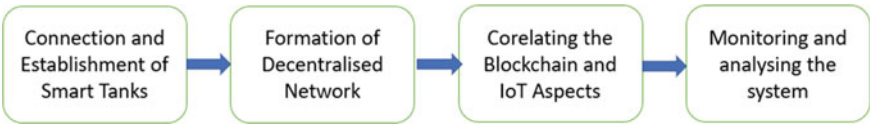

Fig. 1 Workflow diagram for creating an IoT-based Blockchain solution for water leakage management

quality management and lastly identifying leaks in underground pipeline. The devices required are:

- **Arduino board**: The monitoring of the sensors would be done by a concept of Internet of Things (IoT) circuit Arduino. Arduino is an open-source platform which relies on easy and convenient manner hardware and software programs. The hardware reads potential input, input from any connected sensor, a click on a button, or messages (via the internet platforms such as Twitter) and converts it into the required output. The user can send a set of instructions to the micro-controller on the board. The Arduino programming language which is used for writing syntax is the Arduino Software (IDE).
- **Pressure sensor**: The system would require an industry-based pressure sensor. A pressure sensor is a device used for measuring pressure value for gases and liquid. Example for applications for pressure sensor would be in the measuring of combustion pressure measured inside an engine cylinder or in a gas turbine. Pressure sensors are commonly manufactured from piezoelectric materials like as quartz.
- **GPS sensor**: Global positioning systems that can help detect leakage in underwater pipelines without any signal disparity. The global positioning system (GPS) is a satellite-based radio navigation sensor. GPS is a global navigation satellite sensor that gives geolocation and time information to a GPS receiver which provides output anywhere on or near the Earth surface where there is an unobstructed object or line which is in sight to four or more GPS satellite system. Obstructions such as mountains and buildings block the weak GPS signals.
- **pH Level sensor**: To determine the quality of water supplied, we would require a pH level indicator. A pH sensor is categorized as one of the most essential tools that is currently used for water quality measurements. This sort of sensor can gauge the measure of alkalinity and acidity in water and different solutions. The standard pH scale is from 0 to 14. When the pH value is seven, it is considered to be neutral. If pH value is above seven, it represents alkaline substances and substances with pH value less than seven are more acidic.

  For determining the quality and quantity factor of the water supplied within the vicinity, the idea is to equip every water consuming unit (a house) within the decentralized network (a colony or sector) with a smart tank which automatically detects the water level in the tank using hydrostatic pressure level sensors and water quality using the pH sensor. If the water level in the smart tank is below a certain threshold, it fetches water from the main source and thereby checking it quality set by the administrator, and if the water stored in the tank is more than the average requirement, it can be shared within the network among another consuming unit.

ii. **Formation of Decentralized Network**: Here, the entire process is decentralized to make it peer-to-peer and eliminates the need for a middle man. A transparent ledger is then generated to document the specifics of water use and delivery. Wherever the consumer drinks or distributes water, the entry for the same is registered in the decentralized ledger of the network.

iii. **Correlating the Blockchain and IoT**: A pool of water token is distributed to each water consuming unit, and water token are deducted if water is consumed, while water token is earned if water is distributed by the unit.

iv. **Monitoring and Analyzing the System**: The spent and unspent water token details help in data analysis and monitoring the water requirements.

Step by Step Procedure:

The step by step process can be seen in Fig. 2, where the pressure sensor first notes the difference in pressure between the two points and plots the same graph showing the peak value, the precise longitude, and latitude details of the leakage (if any) obtained after identification of the peak pressure value, and the GPS can include the geographical position of the leakage by which we can identify the location of the leakage. A decentralized ledger/record is created where the data (water tokens) of each water consumption unit are stored and can be used for review in a crisis situation; the water level indicator in each tank will assist with the data interpretation of each unit offering a deeper view into the locality's water requirements (Fig. 3 and 4).

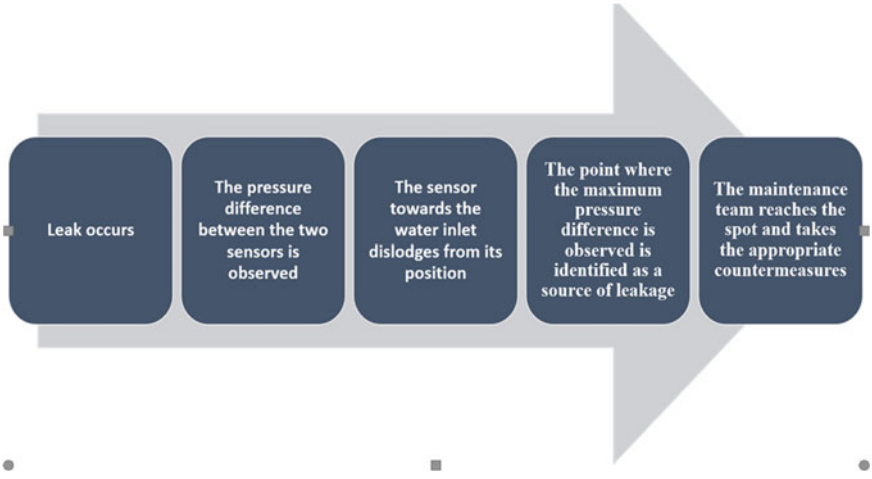

Fig. 2 Identification of the leaks

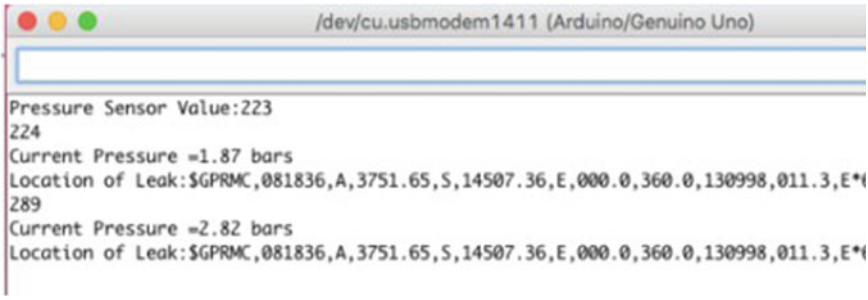

Fig. 3 GPS location and pressure value

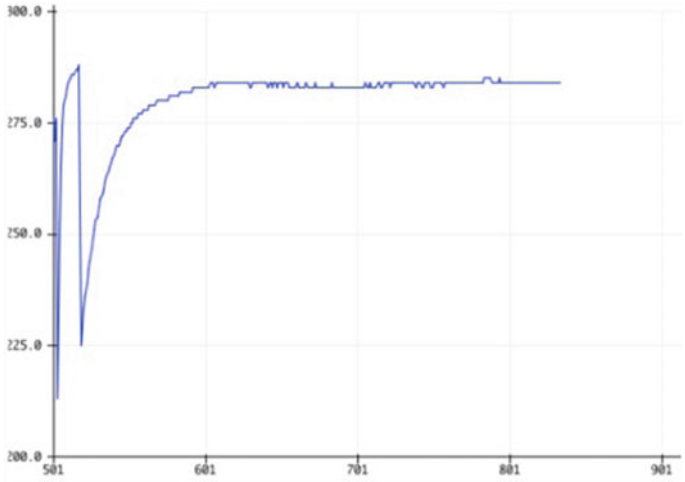

Fig. 4 Pressure sensor graph

4 Implementation and Results

For implementing the smart water management system, a blockchain is created.

By creation of blockchain, we ensure:

- Water requirement for each unit (house) can be recorded and monitored
- Addition and deduction of water tokens
- To provide a valid and secure blockchain mechanism

In Figs. 5 and 6, we showed that how the block chain is created, and the chain of blocks is formed to make the data provenance easy and difficult to tamper, and in Fig. 7, the transactions are shown. Each transaction is hash code encrypted which is not easy to temper.

```
Block's Hash: 99999eeae168b0aef3cb1ee98540246957b78be27937607f089aef8430b86a40
Block added
Simran has 20 water_tokens on her account
The Chain is valid and secure
```

Fig. 5 Creating blockchain

```
Simran started minning
Previous Block's Hash: 999997e5ac38b6ae5b720cd4e325d9ef583502428b8becfe27e1e57f98e896de
['{\n'
 '     "fromWallet": "Zining",\n'
 '     "toWallet": "Alex",\n'
 '     "amount": 0.01\n'
 '}',
 '{\n'
 '     "fromWallet": "Tom",\n'
 '     "toWallet": "Ankit",\n'
 '     "amount": 100\n'
 '}',
 '{\n'
 '     "fromWallet": "Raymond",\n'
 '     "toWallet": "Ankit",\n'
 '     "amount": 1e-07\n'
 '}']
Block's Hash: 99999ea8e9f36c128622bb966115613a7a66aa0802b2d975cf8e3a91e358d84b
Block added
Simran has 20 water_tokens on her account
The Chain is valid and secure
```

Fig. 6 Creating blocks

```
Simran started minning
Previous Block's Hash: 83247c122a3e29320a4e93412c3f76f11d9d3373a471fd183c8cfd61b84fa894
['{\n'
 '     "fromWallet": "Ankit",\n'
 '     "toWallet": "Alex",\n'
 '     "amount": 3.2\n'
 '}',
 '{\n'
 '     "fromWallet": "Ankit",\n'
 '     "toWallet": "Raymond",\n'
 '     "amount": 1\n'
 '}',
 '{\n'
 '     "fromWallet": "Alex",\n'
 '     "toWallet": "Raymond",\n'
 '     "amount": 5.12\n'
 '}']
Block's Hash: 999997e5ac38b6ae5b720cd4e325d9ef583502428b8becfe27e1e57f98e896de
Block added
```

Fig. 7 Transaction

5 Challenges

- The following issues can be encountered during the system implementation and run and the following countermeasures or suggestions can be carried out for better accuracy in the system.
- The longevity of the sensors might vary for every smart tank installed.
- Longevity of the sensors depends on various external factors and quality of the sensor (average sensor life is between 3 to 4 years)
- The working of sensors can be affected due to various factors (water, pressure of water current)
- Need to monitor pressure and other factors on regular basis.
- Installation and retrieval of the system can be tedious.
- It would require a team of 5–6 members for the same and can use additional features of an in-built camera for better surveillance.
- Data collection and analysis of raw data.
- Blockchain technology and its advantages can be well utilized.
- External factors that may vary data.
- Need regular monitoring regarding external factors such as corrosion, pipe structure, and tanks.

6 Conclusions

This proposed paper contemplates a highly accurate and full proof method toward management of water. It assists ways to check quality and quantify water requirements within a sector. The system also identifies leakage in underground pipes along with furnishing the exact geographical location of the leak which helps in taking the required measures appropriately and within the least possible time frame to avoid unnecessary wastage of water. Key features the system showcases are—The pressure difference can be classified into categories to report the severity of the leak. The electronic mechanism shall be enclosed in an air-tight ball-like structure, To reduce response time in sealing, leaks shall provide a lot of direct and indirect benefits. The sensors shall be mounted on the inner walls of the pipes with an electronically controlled switch to dislodge. To identify potential leak sites, the recorded measurements can be timely sent to a central server. A similar device can be used for oil and gas pipeline. Blockchain helps in providing a decentralized ledge and security measures blockchain technology and Internet of Things (IoT) aids the proposed system to function in a coherent manner and provide it with the required contrivance and tools.

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