Design of a Smart Water Storage and Trading Platform Based on Blockchain Technology

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Abstract. A distributed and decentralized smart water storage and trading platform based on blockchain technology for sustainable water supply has been demonstrated in this work. Users in the platform are able to share water resources by selling off or buying in the amount of water that they need. All transactions performed on the blockchain are highly secured and tamper resistance owing to the distributed, decentralized, and immutable features readily available in the Symbol blockchain. This makes the transactions more reliable and cost effective as third party involvement in the verification of users and transactions become redundant. Water is asset tokenized in which users can transact the required amount of water using token without any transaction fee. Cost saving is achieved because a transaction fee is only applicable when the token is exchanged with the Symbol XYM and then converted to conventional currency. Besides, the exchange rate between the token and Symbol XYM can be dependent on the demand and supply of the water instead of a single entity.

Keywords: IoT Smart Tank · Blockchain · XYM Symbol · Sensor · Water Sustainability

1 Introduction

Blockchain Technology has been invented back in the 1990s. The concept of Blockchain is to create a much better and safer way to record our data and information. Prevent the data to be altered, corrupted, or deleted. A blockchain is a digital ledger of transactions that is duplicated and distributed throughout the network of computers that make up the blockchain. Provide a traceable history to the data and everything happens in real-time. The Internet of Things (IoT) [1] is a network of physical devices or people that are connected with software, electronics, networks, and sensors to collect and distribute data. The Internet of Things' objective is to link every feasible barrier to the internet. Smart Water Tank (IoT) is an advanced technique for gathering all the possible water-related data from the water tank [2]. In previous technology, all the water tanks were just to collect the water. After a few decades, it is enhanced to have the ability to monitor the water level in the tank. A water tank provides a convenience for the user to keep their water and determine the water volume. Nowadays in modern society resources and

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materials are continuing to be reduced. People are starting to accelerate the research to develop clean energy. The most significant resource on the earth is water. Water is a crucial resource for every living creature to sustain their lives and the water is getting scarce in pure water. Obtaining clean water is becoming increasingly challenging as the population grows, and everything in our everyday lives is becoming more dependent on water resources. Such as drinking, bathing, and cooking. This project provides an innovative idea for the future to be able to use water resources more efficiently and trade in a better and safer trading system. The objective is to provide more information about the water gathered by the IoT smart water tank and to conduct trade utilizing Blockchain technology. For example, we can determine the purity of the water, transforming rainfall into more variable resources. Every typical family might save a significant amount of water resources. If the water is clean, it will supply another free resource for the user, who may either sell it or utilize it elsewhere. Water waste will be reduced [3]. People will begin to value water more as water waste decreases. Smart Tank IoT can monitor the water and volume in greater detail, allowing the user to see how much water they have previously consumed and collected. Additionally, Blockchain Technology [4] provides a reliable trading method. Everything is transparent, and anybody can view the market and trade price, which will not be monopolized by a single distributor. This is the concept of peer-to-peer trading provided for economic sharing purpose which is aim to provide a decentralized economic model centered on peer-to-peer activities. For instances, the acquisition and provision of products and services between two individuals can be done without the need of a third-party intermediary. A direct trade channel between the buyer and seller is formed, and transactions between both parties are facilitated [5]. In this paper, we propose an energy monitoring and management system that enables users to acquire a tokenized energy token that is called as the WaterExchangeCurrency, which can then be redeemed for water. Users will be able to check and manage their home water use depending on the quantity of WaterExchangeCurrency they have used. Excess energy tokens that are not utilized may be swapped for symbols with other network participants. XYM is a cryptocurrency that has monetary value.

Following are the remaining parts of this article. The related work is discussed in Sect. 2. While in Sect. 3, we have the Methodology and then the Simulation and Results from this study was place in Sect. 4. And lastly, we have our conclusions in Sect. 5.

2 Related Works

Water is the most important resources of life on Earth. Natural water resources are finite, thus it's critical to conserve it and use it carefully. Recent technological breakthroughs, such as the Internet of Things (IoT), have paved the way for new ideas that make it easier to modify existing systems and optimize water supply and consumption. Water level monitoring provides several environmental advantages. Certain companies and organizations must use water wisely in order to improve process efficiency and save expenses. Poor water allocation, inefficient consumption, a lack of integrated water management, and a lack of a sufficient control system are the primary causes of water waste. As a result, for both home and commercial water arrangements, it is critical to have a good system in place that allows for effective water consumption, control, and monitoring [6].

In this work, we would like to propose an IoT (Internet of Things) based water quality monitoring [7] and trading platform based on blockchain technology for the sustainable, safe and clean water supply. We designed an IoT-based water quality monitoring system and trading platform that tracks water quality and trade water in real time. Water quality parameters such as pH, turbidity, conductivity, dissolved oxygen, and temperature are measured by the sensors in this system. The measured values from the sensors are processed by the microcontroller, and the processed data is delivered through Zigbee network to the core controller, which will be a Raspberry Pi. Finally, sensor readings may be viewed on a web browser application thanks to cloud computing.

As an alternative, we propose that the current non-potable water network be converted into a smart water grid to facilitate micro-trading [8], in which families can trade water on a peer-to-peer basis. Rainwater harvesting, putting rainwater "back on the grid" by pumping it into the non-potable water infrastructure system, and purchasing water from neighbours by withdrawing water from the pipe network are all examples of methods that families generate water for themselves and their neighbours. Smart technology such as smart metres, blockchain, smart contracts, and automated infrastructure would make it possible to conduct real-time commerce within a smart water network. It is possible to reimagine the urban water cycle through the use of a rainwater micro-trading system that is programmed within the context of a smart city paradigm. This allows families to act as prosumers by generating and selling water within their community. Making it possible for homes to trade rainwater increases the efficiency of the water cycle by lowering the need to clean and pump reclaimed water from a central facility back into the system. This offset has the potential to save energy as well as recovered water, which can be used in non-potable purposes. Inside the energy market, micro-trading is a viable market for decentralized resource production [9], in which residences generate energy using solar photovoltaic cells, store it in batteries, and then sell and distribute excess energy to neighbours by utilizing existing power distribution infrastructure. The implementation of micro-trading water by providers and local society may be constrained as a result of a number of complicated obstacles.

Blockchains, also known as distributed ledgers, has grown in popularity among energy or resource companies, start-ups, and governments. Various organizations with similar backgrounds believe that blockchains have the ability to greatly innovate while also providing economic advantages. Energy systems have been evolving to effectively incorporate the increased influx of renewable energy sources, with PV installations being particularly relevant. Blockchains were created to allow distributed transactions to take place without the need for a central authority to oversee them. They enable the execution of contracts in peer-to-peer networks on the fly. While Bitcoin is the most widely used and well-known distributed ledger system, Ethereum has steadily grown to become the most often utilized blockchain technology for applications. Ethereum is a cutting-edge distributed ledger system that also serves as a virtual computer that is connected with the cloud platform and comes with its own programming language, incentivizing developers to build apps that use the blockchain architecture as their backbone [10]. Ethereum allows users to design their own smart contracts and intends to provide a versatile platform on which applications involving any commodity transaction may be built. Many projects utilize Ethereum and Ethereum-based digital coins to launch Initial

Coin Offerings (ICOs) as a way to raise funds. The Ethereum ecosystem relies on the integration of smart contracts and decentralized apps that may operate independently. These apps make use of cryptocurrencies/tokens that are exchanged on a network of computers, with the results collected in a public ledger. Since systems like Bitcoin are widely used, maintaining their security, integrity, and functionalities are costly. Because not all applications would require full-scale decentralization, a variety of architectures have been proposed. Blockchains may also be thought of as databases that allow different entities to simultaneously update nodes in a ledger, resulting in numerous copies of the ledger. Instead of a central governing authority regulating the ledger, each member of the network can keep a copy of the records chain and agree on the blockchain's legal status. The specifics of how consensus is reached might vary depending on the situation. New transactions are connected to earlier transactions in the ledger using cryptographic methods, making blockchains a safe platform. Since each user may review their own transaction history, trust and security are assured, as well as the availability of tamper-proof documents. A decentralized system allows a large number of users to engage in local water resource trade by owning water storage. The water resource trade is a way of transferring water from one grid with excess water resources to another grid with deficient water resources. Those with local water resource-producing capabilities might benefit by selling surplus water to other users in the neighborhood during peak hours when water resources are in high demand [11, 12]. This local water resource market supports a variety of company concepts and solutions that improve water resource access and usage [13].

3 Methodology

3.1 Design Overview

The whole flow architecture is shown in Fig. 1, with IoT devices gathering data from sensor array circuits and communicating the data to a website which may collect the data from a real-time database in Firebase and submit it to the NEM Symbol blockchain. Using the Symbol SDK, we will create a web-based water resource monitoring and management platform, as well as a water trading platform that allows users to view and track their water consumption. Users will also be able to perform basic water trading operations without the need for an intermediary. In order to perform IoT smart water tank, sensors that are required are TDS sensor (SEN244), turbidity sensor (SEN0189),

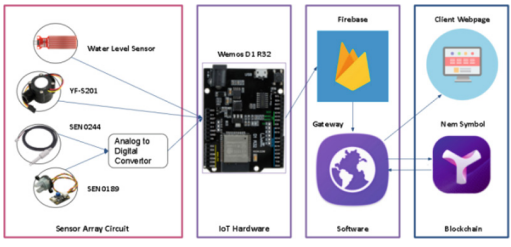


Fig. 1. Overall Flow Diagram

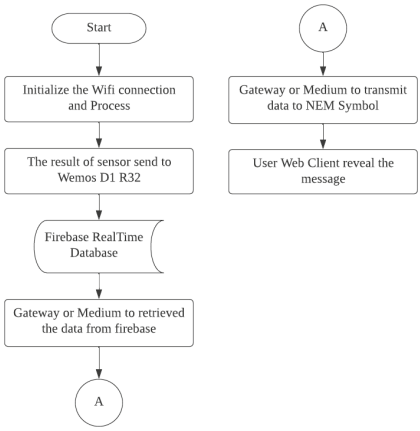


Fig. 2. Application Flowchart

water flow sensor (YF-S201) and water level sensor. The four sensors will collect the necessary data and upload it to the cloud using the Wemos D1 R32. After transferring the data to the Firebase Database, the data will be retrieved from Firebase by the gateway. The primary reason for obtaining data from Firebase is that this project is employing Symbol XYM, which provides a new environment for all developers. They have an API built in that allows developers to create whatever application they desire. After getting the data, the gateway webpage will collect the data and combine it into a string before transmitting the string information and storing it in the Symbol Blockchain using the built-in API which is transfer transaction. After the transaction is done, the user may view the translation that is already recorded inside the Symbol wallet. Furthermore, data had been recorded within the decentralize ledgers, and to retrieve the information in such a long chain, we need the hash value and the user public key. When data is submitted to the Symbol Blockchain system, the hash value in the database is updated. When a person logs into their trade account, they may view the status of their water tank. The public key is collected when the user registers the account, and the hash value is obtained every time the water tank receives a new updated value. The User web page performs the requirements of trading using the built in API from the Symbol XYM which is called as the aggregate transaction. The theory between transfer translation and aggregate translation are different. Transfer translation performs transaction from party A to party B without the concern of party B. For instance, one is sending string data to our water meter (public key) to record the data. In aggregate transaction will be performing trading between the concern between party A and party B in order to complete the transaction, party A and party B need to sign an agreement to perform the trade.

3.2 Software

The software was containing of Firebase, Gateway and Client Web Page (Fig. 2).

The Firebase the mainly use component is the Firebase real time database. The Firebase real time database is a cloud hosted database that able to provide user to store

```
<script>

    var firebaseConfig = {
      apiKey: ".....",
      authDomain: ".....",
      databaseURL: ".....",
      projectId: ".....",
      storageBucket: ".....",
      messagingSenderId: ".....",
      appId: ".....",
    };

    firebase.initializeApp(firebaseConfig);
    var firebaseRef = firebase.database().ref("Member");
    firebaseRef.once("value", function(snapshot){
        .
        .
        .
      }
    })
    window.onload(FetchAllData());
    });
</script>
```

Fig. 3. Retrieving the Data to Web Page

```
function watersending(){
 const rawAddress = 'TATLDZFIR……K7JR25O3HQ';
 const recipientAddress = symbol_sdk_1.Address.createFromRawAddress(
  rawAddress,
 );
 const transferTransaction = symbol_sdk_1.TransferTransaction.create(
  symbol_sdk_1.Deadline.create(epochAdjustment),
  recipientAddress,
  [currency.createRelative(0)],
  symbol_sdk_1.PlainMessage.create(jsarray),
  networkType,
  symbol_sdk_1.UInt64.fromUint(2000000),
 );
 const privateKey =
  '00000……..00000000';
 const account = symbol_sdk_1.Account.createFromPrivateKey(
  privateKey,
  networkType,
 );
```

Fig. 4. Sending Function for (Transfer Transaction)

and synchronize the data in real-time/actual time. In order to manage the real time cloud database, first condition is to create a Firebase real time database in order to store the require data (Fig. 3).

The Gateway is a local webpage act as a medium for transmit the data of the sensor and store into the NEM Symbol Blockchain using API that developed by NEM Symbol developer. Gateway is a local database that retrieved the data from Firebase Real Time database. After retrieving the data from Firebase, it will trigger the API to run and upload all the information from the internal water tank into the NEM Symbol Blockchain (Fig. 4).

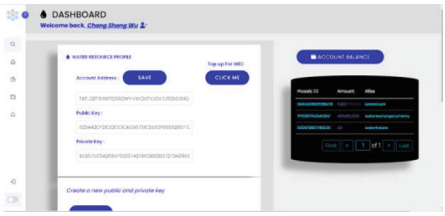


Fig. 5. Dashboard Page

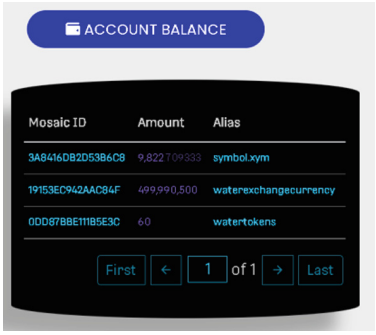
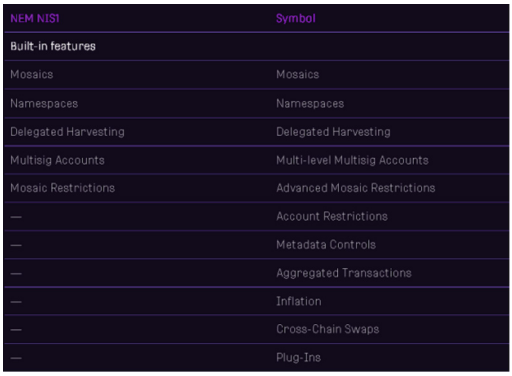


Fig. 6. User Account Balance

The Client webpage has three main pages which are the Login/Sign-up page, dashboard and user water storage page. Client webpage will be the interface for the user client to use. Client webpage in charge of peer-to-peer trading. This client webpage was designed to let the user able to do trading with the distributors and individuals within the community. The unique feature of this client webpage is that all the trading is involved in NEM Symbol Blockchain. It able to retrieve the sensor value from NEM Symbol blockchain and display on the client webpage (Figs. 5 and 6).

3.3 Blockchain

In this paper, will be using NEM Symbol Blockchain. The Symbol Blockchain is the next step in the development of NEM's N1S1 platform. The New Economy Movement group's Symbol [14] project is focused for blockchain-based business use cases. The NEM Symbol is developed in C++ with a different goal from the NEM's original blockchain: NEMNIS1 is the first blockchain platform created by NEM. Through simple yet strong built-in features, it provides versatile and configurable solutions. NEMNIS1 which offers blockchain-based projects using a sandbox-style architecture. Symbol was created with the intention of connecting with businesses interested in entering the blockchain realm. To deploy smart contracts, Symbol uses a layered design and a plugin/extension method that gives users more freedom. The platform was built from the ground up to be scalable and fast. The new platform outperforms the NEM NIS1 Platform in terms of flexibility, speed, ease of usage, low cost and security. Symbol was created with the goal of bridging the gap between business and blockchain (Fig. 7).



NEM NIS1	Symbol
Built-in features	
Mosaics	Mosaics
Namespaces	Namespaces
Delegated Harvesting	Delegated Harvesting
Multisig Accounts	Multi-level Multisig Accounts
Mosaic Restrictions	Advanced Mosaic Restrictions
—	Account Restrictions
—	Metadata Controls
—	Aggregated Transactions
—	Inflation
—	Cross-Chain Swaps
—	Plug-Ins

Fig. 7. Feature Comparison between NISI and Symbol

The Symbol SDK (software development kit) is using mainly the 3 languages that most of the developers used. Which is Java, JavaScript, and Typescript. NEM's Symbol is designed to be interoperable; it allows public or private hybrid models, trustless cross-chain swaps, and its Application Programming Interfaces (APIs) to connect seamlessly with current systems and processes. The atomic cross-chain swaps eliminate the need for middlemen by allowing trustless data and value to move across several blockchains. It also allows the production of specific digital assets, including shares of stock, signatures, votes, non-fungible tokens (NFTs), and other currencies, in addition to tokens. Each asset has adjustable features and a unique identity, and at the protocol level, it may apply logic-based account or asset-based limitations. These capabilities have enormous promise in the new economy movement, particularly in the Decentralized Finance (Defi), Regulated Assets, and Security Token Offering (STO) arenas, with Symbol currently linked with Propine, a regulated Security Token issuance, and custody platform. While Symbol uses the same underlying ideas as other blockchains, it adds features that have not been seen in other commercially accessible blockchains, as well as employing distinct core cryptographic methods and consensus. The following is a list of characteristics that have been employed in the construction of the energy trading system. The function that will be mainly use in this project will be MultisigAccount, Transfer Transaction, Aggregation Transaction and Decoding Messages.

The Multisig Account is a particular type of Symbol account with its own set of regulations. Multisig account may be thought of as a child account of the related cosignatory accounts. This implies that in a multisig account, transactions must be cosigned by the cosignatory accounts in order for the transaction to be broadcast to the network. This multisig control allows several parties to share asset ownership in a variety of ways.

In Symbol, user Alice can send a fixed amount of funds (mosaic X) to user Bob with a public message or encrypted message in example: Alice sends 10 symbol.xym to Bob, with an attached message of "How are you?" (Fig. 8).

Multiple assets can also be transferred in the same transaction as well. For instances: Alice sends (mosaic X, mosaic Y, and mosaic Z) to Bob. Bob receives three different assets (mosaic X, mosaic Y, mosaic Z). The messages connected to transfer transactions are accessible to all network participants by default, and each transfer transaction can

carry a message of up to 1023 characters. Encrypted messages, on the other hand, can only be read by the sender and the recipient.

One of Symbol's features is the ability to create a one-time disposable smart contract that enables trustless exchanges. All of the inner transactions are executed at the same time after all of the participating accounts have signed the aggregate transaction. The public network can handle aggregate transactions with up to 1,000 inner transactions and up to 25 distinct signatories. A multi-asset escrowed transaction is another name for this. Two parties can agree to initiate a two-way transaction without completely trusting each other by using an escrow contract. As long as both parties sign the aggregate transaction, the exchange of assets and monies can take place right away (Fig. 9).

Example of scenario: Alice wants to buy a ticket. Alice and the ticket vendor agree on the terms. An escrow contract is created. Alice puts an agreed amount of symbol.xym (money) into the escrow. The ticket vendor delivers the ticket (mosaic) onto the escrow. Alice approves the goods or services. The escrow releases the payment to the ticket vendor.

Symbol encrypts and decrypts messages using Bouncy Castle's AES block cypher implementation in CBC mode4. If Alice possesses the private key kA and wants to encrypt the message for Bob, who has the public key Ab and the matching group element Ab, the shared secret is determined as shown in Fig. 10.

In this project the decoding function will only be use. The decode messages required the hash value from the message sender in order to decode the original message.

Fig. 8. Transfer Transaction between two accounts

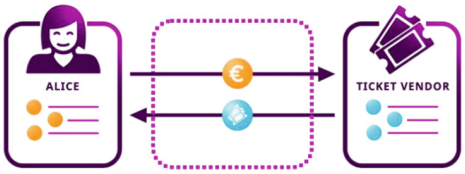


Fig. 9. Multi-asset aggregate transaction

$$
\begin{aligned}
a_A \textit{ is computed from } k_A \textit{ according to } (2)\\
salt = 32 \text{ random bytes}\\
G = a_A A_B\\
\textit{shared secret} = \ddot{H}(\underline{G} \veebar salt)
\end{aligned}
$$

Fig. 10. Bouncy Castle's AES block cypher

4 Result and Discussion

In this section, the overview of the circuit diagram for the IoT hardware.

The Fig. 11 show the circuit diagram connection for TDS sensor (SEN244), turbidity sensor (SEN0189), water flow sensor (YF-S201) and water level sensor.

Figure 12 show the serial print values that generate by the sensor and captured by the Wemos D1 R32.The turbidity display shows the percentage of the data that send from Wemos D1 R32 to Firebase. The turbidity sensor monitors turbidity, often known as opaqueness, to determine water quality. It detects suspended particles in water by measuring light transmission and reflecting rate, both of which are affected by the amount of total suspended solids (TSS) present. As the TTS rises, 43 so does the quantity of liquid turbidity. Quality of water in streams and rivers, as well as wastewater and effluent assessments, settling pond management tools, soil infiltration studies, and laboratory tests, all employ turbidity sensors. Both analogue and digital signals may be generated by this liquid sensor. The threshold may be modified in digital signal mode. You can select a model based on the Wemos D1 R32.

The water flow speed and total water is generated by the water flow sensor. A water flow sensor is an electronic component that determines how much water is flowing through it (Fig. 13).

Furthermore, the flow rate is the amount of water that passes through a sensor in a given length of time. Determined the liquid flow rate equal to $Q = VxA$. Q is the flow rate/total flow of water. The V represent as the average of the velocity of the flow. The A is the cross-sectional area.

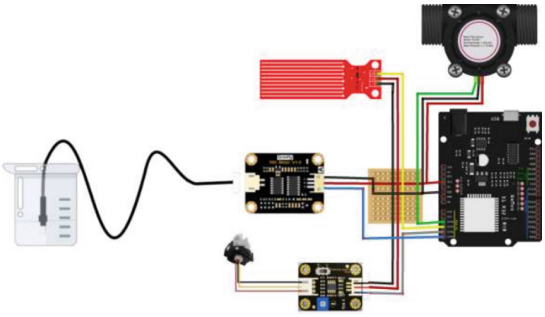


Fig. 11. Circuit Diagram for all Sensors Connection

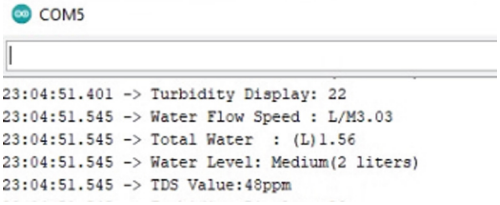


Fig. 12. Sensor Value gets from Wemos D1 R32

Sensor Frequency (Hz) = 7.5 * Q (Liters/min)
Litres = Q * time elapsed (seconds) / 60 (seconds/minute)
Litres = (Frequency (Pulses/second) / 7.5) * time elapsed (seconds) / 60
Litres = Pulses / (7.5 * 60)

Fig. 13. The Formula to Determine the Water Flow Speed and Total Amount of Water

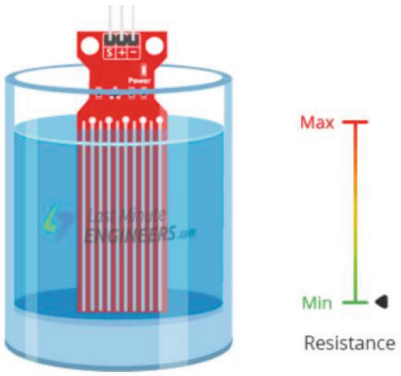


Fig. 14. Water Level Sensor Behaviour [15]

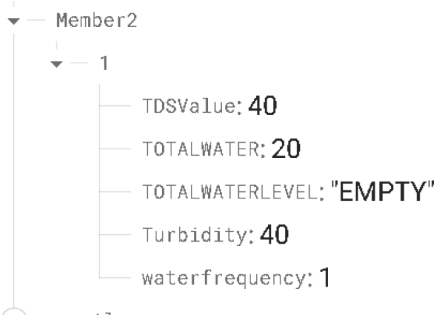


Fig. 15. Sensor Value that uploaded to Firebase Real Time Database.

The water level will be determined by the Water Level Sensor (YF-S201). The parallel wires of the water level sensor act as a variable resistor same as a potentiometer when resistance changes, water level changes. The distance between both the above of the sensor's and the water's surface determines the change in resistance (Figs. 14 and 15).

After collecting the needed sensor values, the Wemos will upload all of the data to the Firebase real-time database in order to save the data in the Firebase.

The data that was retrieved to gateway and then it triggered the API to run (Fig. 16).

After the transaction announces response is completed, the sensor value will be stored in Symbol Blockchain in the manner shown in Fig. 17.

The retrieving function that gets the message from Symbol XYM to user client page (Fig. 18).

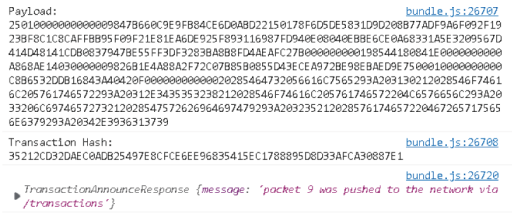


Fig. 16. Transaction Announce Response in the Web Console

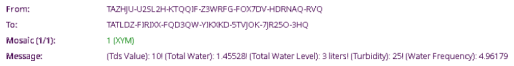


Fig. 17. Sensor Value Store in NEM Symbol Blockchain

```
function getmessage(){
const transactionHash =
  getmessageq; //The Transaction Hash
transactionHttp
  .getTransaction(transactionHash, symbol_sdk_1.TransactionGroup.Confirmed)
  .pipe(operators_1.map((x) => x))
  .subscribe(
    (transaction) => {
      console.log('Raw message: ', transaction.message.payload);
      getmessagebac = String(transaction.message.payload);
      sessionStorage.setItem("getmessagebac", JSON.stringify(getmessagebac));
    },
    (err) => console.log(err),
  );
```

Fig. 18. Get Message from Symbol Blockchain

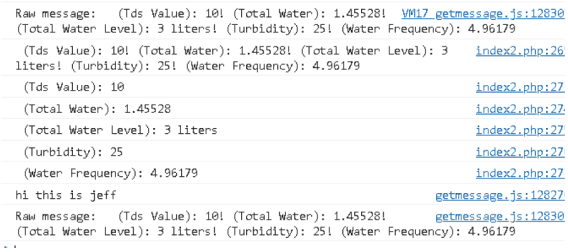


Fig. 19. The Console Log of Sensor Value Retrieved to Client Webpage.

When the software encounters an exclamation mark (!), it splits the message using the string split function. Figure 19 depicts the string and data that were divided.

Figure 20 shows the information displayed inside the user client page for the water tank information that had been retrieve from Symbol Blockchain.

The features of the client website not only allow the user to trade, but also give information on the water tank that the customer has installed in his or her home. Because of the blockchain storage technology, the data will be protected and more secure. The information that shown in Fig. 20 is the client page for observing the information of the internal stimuli of the water tank.

Fig. 20. Sensor Value that Display for User to Observe

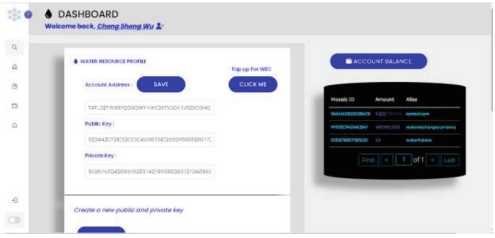


Fig. 21. Dashboard of Client Web Page

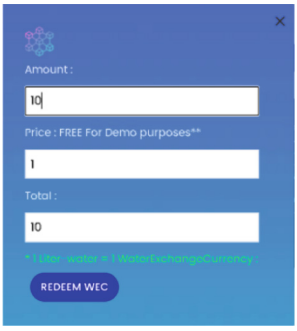


Fig. 22. Transaction between Distributors and Buyers

The Dashboard page displays the user's public key, account address, and private key. When the "CLICK ME" button is pressed, a small window for trading the WaterExchangeCurrency using Symbol XYM appears, as seen in Fig. 21.

Figure 22 depicts the user's ability to conduct trade between distributors and themselves. The amount is the desired WaterExchangeCurrency. The pricing is a fixed price that wholesalers must adhere to. The total is the amount of the entire Symbol.XYM for which the user must pay.

The Fig. 22 shows that after the user pressed the redeem WEC button it will run the API in order to generate an aggregate transaction between user and distributors. The aggregate transaction in Fig. 23 is shown under the Symbol Wallet Application (Fig. 24).

From:	TATLDZ-F1RIXX-FQD3QW-YIKXKD-5TVJOK-7JR25O-3HQ
To:	TAZHJU-U2SL2H-KTQQ1F-Z3WRFG-FOX7DV-HDRNAQ-RVQ
Mosaic (1/1):	1D (XYM)
Message:	You redeem Symbol_XYM

From:	TAZHJU-U2SL2H-KTQQ1F-Z3WRFG-FOX7DV-HDRNAQ-RVQ
To:	TATLDZ-F1RIXX-FQD3QW-YIKXKD-5TVJOK-7JR25O-3HQ
Mosaic (1/1):	1D (waterexchangecurrency)
Message:	You redeem WaterExchangeCurrency

Fig. 23. Complete Aggregate Transaction between Distributors and Buyers

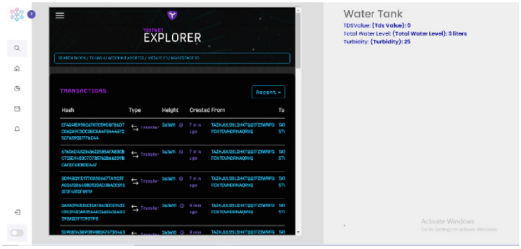


Fig. 24. Sensor Value Retrieved from NEM Symbol Blockchain to Client Webpage.

5 Conclusion

In this research, we offered an all-encompassing system for our everyday lives, ranging from hardware to media to software. Providing a smart tank as well as a more secure and safe method of storing essential data on the internet. Most significantly, creating a better environment for users to reduce water waste while also maximizing the benefits delivered to users and distributors.

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