Blockchain-based multi-organization taxonomy for smart cities

Ekleen Kaur¹ · Anshul Oza¹

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Abstract

With the tremendous development in distributed ledger technology, assimilation of tokenization in sustainable assets has been a proof of concept. This paper is a documentation of ERC20 standards where cryptocontracts are an evident implementation of WRC tokens. Issuing and earning of these token credits rely on aggregate hazardous waste released into water as a by-product and careful monitoring of water quality standards (after treatment) using IOT sensors. The minting of this token currency is put forth by exchanging ether. This research is twofold attempt to eliminate the differences between Small and Medium Enterprise and large-scale Enterprises and to establish a business ground with equal opportunity of earning credits based on recycled wastewater.

Keywords Blockchain · Water analysis · IOT sensing · Permissioned blockchain network

1 Introduction

Distributed ledger technology has progressed after Satoshi Nakamoto's offered solution to double spending problem by implementing peer-to-peer transaction after mining the first block [1]. Blockchain technology has continuously evolved since then; blockchain is nothing but cryptographically linked blocks storing information. Each block contains a cryptographic hash of the previous block, a timestamp, i.e., the time at which the transaction was confirmed after successful mining of blocks and transaction data. With the advent of blockchain came the concerns about the anonymity of miners and the organizational theory of decentralization [2]. Decentralized governance revolves around transparency and trust among the members. Blockchain has 4 major features:

Immutability Once the data of a transaction is confirmed and recorded, it can never be changed or amended. The same asset can undergo various other transactions adding to the list of confirmed recorded transactions,

but the state of those confirmed transactions remains immutable.

Provenance Immutability of recorded transaction gives provenance of assets, providing an entire history of the asset, including where it has been, who or how many members have owned the asset previously and so on.

Consensus This weeds out potentially fraudulent transactions out of the database. A transaction cannot be confirmed on a blockchain without consensus. The consensus is very important for the validation of a transaction.

Distributed It urges various organizations to share and exchange data.

Smart contracts are the building pillars of blockchain in a business organization. Inside distributed ledger technology, we audit the smart contracts built for blockchain, at which it is designed to be implemented [3]. Ethereum is a well-known public as well as private blockchain network. Ethereum demonstrates a successful implementation of a complex Merkle tree, i.e., Merkle Patricia tree. Ethereum works on PoW (proof of work), PoS (proof of stake) and PoA (proof of author-

✉ Ekleen Kaur, ekleenkaur17@gmail.com; Anshul Oza, ansuhuloza@ipsacademy.org | ¹IPS IES Academy, Indore, India.

ity) consensus algorithms. In terms of efficiency, PoA is considered more robust than PoS [4]. PoA allows non-consecutive block approval from any one authority. Ethereum is usually taken to a permissionless blockchain network just like bitcoin.

A permissionless blockchain is a network in which anyone can become a member and take part in consensus, add a new block and confirm new transactions. A permissioned blockchain allows 'any node' to take part if the identity and role are defined, whereas a private blockchain only allows 'known nodes' to participate in the network.

ERC20 is the standard used for smart contracts on the ethereum blockchain for implementing tokens. Crypto tokens are a special kind of virtual currency that represent an asset or utility. Tokenization of assets [5] on blockchain is creating tokens using smart contracts based on some standards, i.e., ERC20 in this case and regulate those tokens by writing functions in the contract that allow the token to be traded and exchanged in the form of currency or in the form of an asset. Each token item is a hash value representing a crypto asset, which is under the consensus of all consortium members. Typically, a token contains both direct access and user authenticated access. Hash value in the token is made available only on the regulator's or owner's authentication.

ERC20 token standard is complemented by ERC223 [6] and ERC777 [7]. Just like ERC20, there are many other smart contract-based token standards such as ERC721, ERC1155, NEP5, NEP11, QRC20 although ERC223 and ERC777 are very analogous to ERC20. Tokens dealing with smart contracts involve two function calls under ERC20, and on the other hand tokens working on ERC223 and ERC777 fashion involve only a single function call. Despite a few advantages, ERC20 is still prominent over ERC223 and ERC777.

Now the implementation of code in a smart contract is done using solidity. Solidity is a high-level contract-oriented programming language. It is used to build smart contracts. Solidity works on the principles of object-oriented programming just like any other programming language like C++, Java, Python, etc.

Smart contracts are necessary for the regulation of a business network for the purpose it was meant to fulfill. Tokenizing sustainable assets are being developed under great examination, such sustainable assets contribute to waste management and establish sanitation. Improperly treated wastewater is one of the largest sources of water pollution in India [8]. Water quality and pollution are generally measured in terms of concentration [9]. So, waste management mainly revolves around the non-biodegradable constituents which are required to be treated.

Overview of some major types of wastewater chemical contaminants include:

- (i.) *Total Dissolved Solids (TDS)* Comprises of inorganic salts and small amounts of organic matter dissolved in water.
- (ii.) *Biochemical Oxygen demand (BOD)* Amount of oxygen required by aerobic microorganisms.
- (iii.) *Chemical Oxygen demand (COD)* Oxygen equivalent of organic matter content susceptible to oxidation by a strong chemical oxidant.

Identification of water quality is done, based on some standards:

- *PH Scale* used to specify the acidity of a solution. Normal water has a PH nearing 7.
- *Turbidity* It is the measure of the degree to which water loses its transparency due to the presence of suspended particulates (size greater than > 1000 nm). Turbidity is measured in NTU's which stands for Nephelometric Turbidity Units.
- *Biochemical Oxygen demand (BOD)* 3–5 particulates per million for normal water.
- *Total Dissolved Solids (TDS)* For normal water, the value of total dissolved solids is 300–500 mg/liter.
- *Temperature (°C)* This property has a varying range based on the type of microorganisms perpetuating. Industrial water has psychrophiles in 0–20 °C, mesophiles in 10–45 °C. Normal water body has a temperature of 13 °C.
- *Hardness and oil/grease* Normal water ranges less between 45–46 mg/l and 5–6 mg/l correspondingly.

Now that certain quality standards have been established, the question arises about what to monitor the water quality standards with?

As sensor technology advances the whole system of everyday challenges is easily implemented with advanced solutions. Internet of Things (IoT) possess ability to transfer data over a network at high speed with great accuracy. IoT sensors are devices that record data and provide new insights by monitoring data. IoT sensors play a big role in monitoring the water quality, the reason why it is significant to convert the data recorded by the sensors into useful information and to deploy this information for interaction between stakeholders [10].

1.1 Challenges with wastewater management

- *Inadequate treatment of water* Since there are organizations that are already recycling wastewater, these

organizations do not realize the need for amending the current systems. Due to the inappropriate treatment of wastewater, the water quality standards are never met that can be reused by the company to profitable amounts.

- *Lack of careful monitoring* The major reasons for inadequate treatment of water is due to the lack of an efficiently established monitoring system that can regulate these organizations and regularly keep the water quality standards under check.
- *No incentive earned* As of now, India lacks a well-established wastewater monitoring system that can provide an incentive to the organizations that are a part of the business network.
- *Freshwater Dependency still intact* There is no major monitoring of the treatment plants, so the resultant recycled water is of no major use to the organization itself, due to which the freshwater dependency of such organizations is still intact. Correspondingly, the probability rises that the major pollutants are still present in water.

2 Literature review

Swan [11]: Melanie Swan writes the manifestation of blockchain and how it is soon going to take over the economy, the crucial necessity of decentralization in business, also token exchange that has been evolving since the arrival of blockchain and how vast the magnitude of the functionality of a smart contract in business is. However, blockchain technology is only limited to theoretical terms, and its potential is defined without a scope of the actual implementation. The book is a beginning ground for the new economy that majorly lacks the actual complexities of guidelines to implement blockchain tokenization on a protuberant scale; the real-time challenges are just briefly mentioned.

Mougayar [12]: William Mougayar surrounds blockchain around exploring the new ways in which it is capable of extending its service in business and economies, solving the contortions of Melanie Swan's [11] work. In our research, our real-time asset, i.e., wastewater is getting monitored by IOT applications and traded as tokens; we cite this book to further blockchain's immense capability in business to resolve larger problems that current centralized authorities are facing in the present time such as maintaining water contamination and establishing real standards to monitor the treatment of wastewater. William Mougayar's paper doesn't discuss the shortcomings of extending blockchain as a service or provide real-time solutions to those shortcomings.

Duca et al. [13]: The paper states the self-purification of water, hydrochemicals that are essential for determining water quality and how the concept of mineralization works, a very detailed illustration of H_2O_2 as an oxidizing and reducing agent and radical formation across chemical bonds, modeling of these chemical links in the interim of redox reactions along with the role of transition metals in quasi-reducing state. The author pens down the fact that the dependency of self-purification on OH radical is directly proportional and biotic components in water play a key role in self-purification. Gheorge Duca's Paper in the year 2008 points to the efficiency of the detailed water purification processes; blockchain's architecture for smart cities as discussed in our research empathizes with this fact of monitoring the water purification standards while growing the business economy. We engross the acceptance sampling to target the set of organizations with previously set up water purification management systems, and our research aims at monitoring this efficiency in a business network as we discuss in Sect. 3 of this paper.

Echard [14]: The data in a business network is prone to attack; the author talks about the importance of encryption and the chances of vulnerable data, the need for security keys and the decryption of data. The conclusion speaks of hazy ideas regarding the security of data over a network. Due to the presence of malicious crackers, data are never too safe or completely secure on a network.

Schaad [15]: This paper is an additional focus on devices that form a major part of Internet of Things today. Data modeling using binary data, the signing and encryption standards of objects (COSE), after amending from JOSE, well-defined basic COSE structure, multi-signature on objects have been a part of the modern updates. Signing and verifying altogether with encryption algorithms, the author also explains signature algorithms while defining security aspects and authentication. COSE's registries and Media Type explain the usage of keys in IOT-based applications and are very necessary while maintaining security standards.

Echard [14] mentions data security on a network connecting IOT devices; Schaad [15] advances his work by COSE protocol encryption for cryptographic signing of data, enhancing data security; COSE protocol follows layer encryption, i.e., content and recipient layer. Our work uses cryptographic encryption for ethereum blockchain which uses Elliptic Curve Digital Signature algorithm as a key pair encryption standard for unique public and private key pairs owned by each organization.

Hong et al. [16] exemplifies policy-making complication given a local government that stands as a regulator, emphasizing schemes and target-based production results. The game model theory puts wealth and welfare with equal importance. The paper promotes the reduction

of hazardous emissions at the stake of adopting green technology inside big firms. The complexity of the problem case is analyzed depending upon the initial allowances which are expected to be clearly defined. Hybrid algorithm composes of polynomial dynamic programming (PDP), genetic algorithm (GA), and it also consists of binary search in matters relating to the efficiency of the business model on the ground of policy making. In the business trade, the paper states about firms exchanging allowances which are used either to sell or to buy; this theory is functioning in our research. Consensus on blockchain ensures decentralization, so in a decentralized business network exchanging of these allowances is aiding to the circulation of the token economy that resolves the big question of the token trade between organizations.

Zecchini [17]: This paper extends the above-proposed business model governed by a regulator in its research. The author clearly defines the problem statement of water impurity standards and how IOT can help in revolutionizing data elucidation. The merits and demerits of a regulator organization like the government are well elaborated and authentically structured; the entire thesis of the storage of data and transmission is through low power wide area network and efficient comparisons with other data transmission techniques and its architecture. Cryptographically encrypting data storage while laying out the merits of blockchains, the analysis of a permissioned blockchain over a permissionless blockchain, the rules for establishing quality credits to offer incentive in exchange of water quality has been just theoretically defined by the author. His future works include the implementation of permissioned blockchain for quality credit. Our research on multi-organization blockchain taxonomy establishes proof for practical implementation of smart contracts over permissioned blockchain network and a profit formula for anticipating quality credit along with the token price.

Silvestre [18]: supply chain ambiguity and stimulating factors are certain management challenges faced by the economies which eventually hinder the sustainable growth of such economies. The research has a description on the geographical factors that affect the social demands and their roles in supply chain. Even though the rise of globalization in complex business networks is facing high uncertainty, all are promoting stages in aggrandizing green technology in sustainable business networks.

Klassen and Vereecke [19]: Silvestre's [18] work in sustainable development of economies in supply chain results in expanding business which is associated to certain complexities. Compared to Silvestre's work, this paper proposes that supply chain risks and social responsibility are inter-related terms. The social intervention leads to increasing risks alongside opportunities. Social responsibility must include close monitoring of customers'

demands and supplies. Collaborative decentralization offers flexibility of workflows and processes; organizations with too many regulations face human health challenges. Innovation strategies involve management policies and product innovations that legitimize performance. Responsibility extends to auditing social standards by stakeholders that include alignment of risks and profits combined. We differ in this context because auditing social standards in order to increase sustainable business needs to be maintained; smart contract in our business model maintains those standards. The most important factor is which organization owns what quantified amount of the sustainable asset chosen in the model, i.e., the waste water token.

Li et al. [20]: Tokens are classified depending upon the work it was supposed to fulfill. Utility tokens are the currency base of applications, determining access control of the application. Security tokens derive its value on the top of blockchain, externally, but it can be subject to mandatory surveillance and supervision. Asset-backed are tokens converted from real and virtual assets under open asset protocol, a policy backed token offering privacy conservancies on data. Recorded data on the ledger can be only traded. Our research uses a real-world asset as an asset-based token implemented on ERC20 standard with the token contract laying the rules of ownership. The contract provides proof of ownership which can be transferred if the ownership of the recorded data is specified with its quantified amount given that the amount is less than the total available token balance of that particular time stamp.

Zhou [21]: Data ownership in a permissionless blockchain is proposed using a Dlattice architecture of a Double DAG, as the presence of an Account DAG data security is immune to influence from other accounts. DPOS-BA-DAG protocol establishes decentralization by consensus in the presence of forks. Tokenizing data is given because of Dlattice in the paper with consensus in the time period of just 10 s. The author compares the economic incentives of Algorand protocol, a large amount of signature data, and establishes comparisons between various consensus protocols like fault Tolerance, Ouroboros, etc. Dlattice aims to extend healthcare with the help of IOT, exemplifying our research on sustainable assets; however, IOT supervision in our business model is a part of permissioned network that uses proof of authority consensus. According to the paper, the Account DAG structure allows same user to own multiple accounts where each account has a separate public key as an identity, but this is not the current possibility in our blockchain architecture because multiple accounts owned by the same organization enterprise is irrelevant and it may lead to loss of track on records on monthly quality credits and penalties issued to the organization.

Sánchez-Corcuera [22]: The smart city application faces many challenges; sustainable assets cater risks that

can outweigh its benefits as discussed by Klassen's [19] research in 2012; these risks are only going to augment in the future. Urban planning is comprehended by sustainable factors revolving around the environment. Waste management, as stated by the paper, discusses different approaches like smart containers and new infrastructures but does not include authority access and data transparency, which is a major feature evident for smart cities. Data tokenization, consensus on blockchain, is a big solution to these problems.

Kundu [23]: Kundu Debasish supports and proves Sánchez-Corcuera Ruben's [22] work; transparency is a key factor for an efficient smart city despite the available set of technologies carrying the society in the imminent time. To establish transparency and trust which is the building of any business contract, smart contracts or cryptocontracts direct the workflows and access control of transactions, which we implemented for tokenizing WRC—wastewater recycling certificates. Access control has a lot of contortions in token trade, defining the rules of data ownership [20], such as

- Who has the right to mint ether,
- Who has the right to withdraw back from the token amount back to ether,
- Who can send and regulate transactions,
- What is the minimum token price each organization must own in order to be a part of the network.

The author elucidates the importance of transactions without third-party intervention liquid economy that tokenizes land base assets allowing the transferring of such assets at a much faster and safer state. We focus our findings on the basis of the four layer topology as discussed by Kundu Debasish.

Kouhizadeh [24]: Circular economy in a supply chain using blockchain technology can help monitor and keep a record of previously deleted products, by storing the record of each transaction on the ledger and helps keep track of all updates. Circular economy subsidizes exchanging of products. Blockchain's shift over renewable energy has helped reduce emissions on environment. The author states about waste exchanges supplementing blockchain. Accessing products, transaction records, final stage data, by-products are all potential aspects of blockchain based waste management. Data tokenization managed by local governments or semi-government bodies namely regulator is the prime proposal of our research. Detailed elucidation of complex inter-relationships advancing toward development in circular economy which are defined in terms of participant owned assets and regulator regulated transactions. One of the major differences is that the author claims on using blockchain as an alternative

for product deletion, whereas our major closure is on using blockchain as a restate for resource elimination; wastewater cycle extends the capacity of these potential resources for a more optimized utilization by organizations.

Savelyev [25]: Kouhizadeh Mahtab proves discarded products in a supply chain can be regulated as a circular economy on blockchain [24]; Savelyev discusses these blockchain economies in association with the legal aspects ascending within such businesses. The paper clearly discusses tokenization of assets that can be registered on a network working on blockchain; tokens function according to the rules essential for the business network in a blockchain architecture. What is evident is that the author discusses about the possibilities of providing tokenized assets some cognizable rights that are recognized for every token economy to inherit and transfer. It is lucid from the paper about the existence of certain anomalies related to the ownership of blockchain tokens that are still being analyzed to legalize tokenized assets in the future. Our research manifests blockchain mining; sustainable asset solves the problem of ownership [20] of the tokenized asset at the time of transactions which eliminates a major research gap, since our research is not tokenizing private property or objects owned by organizations.

Blemus et al. [26]: Increased transparency with the intervention of distributed ledger technology has improved governance. Token economy is raising ICO (Initial Coin Offering) investment; ever since the distributed ledger technology has stepped into business the amount raised has been progressing on the graph. The author mentions token rights specific to the issuing of tokens; our research is apropos for providing rights to identity of ownership of tokens that are issued by the regulator symbolizing a successful quality check and utilization of wastewater. Corporate governance using tokenization on blockchain is just a theoretical survey in the paper, without signifying major protocols involved. Similarly the paper briefly mentions about the establishment of a relationship between tokens and economic/noneconomic ecosystem by proposing IOT as a solution medium to develop that link but there is no further progress in the research in this regard.

Roth et al. [27]: Blemus et al. [26] and Li et al. [20] classify tokens as security, utility and crypto tokens similarly. The author makes an interactive comparison between UTXO-based, layer-based and smart contract-based tokens. The paper contemplates the impact of tokenizing assets on blockchain by eliminating the need of a platform provider or a third-party authorization for transactions to enforce. The paper briefly mentions regulatory issues of legal policies but majorly focuses on crowdfunding equity using blockchain. Wastewater is not only quenchable to the need of crowdfunding in our research but also retorts the problem of asset ownership even though it is not a

catechizing factor in our research. Our research highlights toward the innovation of using wastewater as a circulating business economy. Crowdfunding is a major problem in the business economy; the author proposes solutions to the problem of crowdfunding using blockchain. Blemus et al. [26] points to the monopoly of token stakeholders that form a major part in any corporate governance, and Roth et al. [27] contravenes this fact by providing an analysis of market capitalization of various blockchains with ethereum token market capitalization at the maximum; his findings justify the safety of assets from arbitrary manipulation and monopoly of token holders in a network using blockchain; the end of this section sums up our differences with this research.

Sanghavi et al. [28]: The author proposes to employ the asset tokenization in quotidian phases and decision making in an organization, with just a glimpses on the fact of an actual possibility. Our research to bolster the above facts focuses on implementing the amalgamation property of cryptocontracts and proposes a touchstone to enhance governance in the regulation of enterprises or organizations that lobotomize over time. Taking the above facts into consideration, the author acknowledges possibilities without results. The author lacks significant results regarding decision making process within the business network and makes predictions without any expert review which has no value.

Prince Michael von und zu Liechtenstein [29]: According to the paper policies to be put forth under the blockchain law, as planned and argued by the Liechtenstein government, majorly involves the embryonic idea of token-based economy. The vast ground of asset tokenization has extended to a large scale in the context of business; cognizable blockchain rights ameliorate degree of trust amidst organizations. Apart from immutable data and security due to data enciphering, blockchain law contradicts all the belied theories of losing copious amounts of money due to bugs or lack of proper auditing of smart contracts that in the past has resulted in the loss of millions of dollars. The author extrapolates tokenization as a method of establishing a trust to bolster entrepreneurial participation in blockchain environments. There is a major research gap; it doesn't provide an actual plan on how the token economy will be regulated once the law is imposed.

Davydov and Khalilova [30]: Unlike Liechtenstein's [29] proposal of cognizable rights for blockchain, the author mentions the incrementing possibilities of money acquisition for the banks and also P2P market services by proposing a business model creating entrepreneurial opportunities. The research gap is lucid from the paper for not discussing any of the legal aspects indulged with the bank loan amount upon tokenization. The author's finding attenuates the research because of a lack of sufficient

result that could actually supplement the theory proposed or some amount of implemented result that could dwell the readers' trust on the less probability of money lost due to tokenization, which the author fails to accomplish. There is a significant probability of money getting lost in the proposed business model; it is not reliable under load conditions.

Levin [31]: The author mentions about the low liquidity property of smart contracts. The four steps involved in asset offering include the process of digitization, tokenization, asset trading and dealing. With the instance of APT tokens in the paper, the author mentions the contingency of escrow accounts that hold in actual assets compatible with the ERC20 standard. Some key emphasis is on information transparency that enhances trust and promotes the sales market; tokenization is cogent in the present-day economy because it deals with the problem of high capital investment. Escrowing assets save the property from rental scams. The author discusses the potential of cryptocurrencies to be traded as real-time assets but the research gap is that it lacks many possibilities and the instances fail to sufficiently extend the theory. The author has provided no relevance of multi-signature wallet in escrow account holdings to uphold its credibility.

To sum up, the above papers extend various aspects of blockchain; they deal with many of the incoming challenges rising with the diversification of blockchain in the modern day ecosystem. This research is another aspect to extend blockchain's capability for business; however, none of the aforementioned research builds token economy with IOT using a sustainable asset. We tokenize wastewater on ethereum due to its largest market capitalization; to the best of our knowledge, this is the first research that builds such a business model on private ethereum network using POA consensus.

We deal with the challenges on introspection; IOT monitoring of water quality in a POA network has a regulator; Proof of Authority Consensus demands the presence of authorities to approve transactions for the issuing of quality credits. For this regard, we concern those organization having favorable outcome in the quotidian scrutiny.

Section 3 of this paper provides our work for smart city modeling; finally, we provide our discussions in the conclusion section that highlight the crux and summarize the research.

3 Methodology

Sustainable energy credits are composing into business. Tokenizing these energy credits for business on ERC20 fashion has some verdicts that need scrutiny. India has many organizations utilizing freshwater for commercialism

with detailed and well-structured water treatment platforms.

Problem case

- The dependency on freshwater is still intact.
- There has been no considerate curtailing of waste emission in water bodies.
- There is a need for regulator [16] that can monitor and examine the water quality standards.
- The organizations purifying wastewater need to reuse that treated water for merchandising.
- We need a profit formula for the reuse of corresponding recycled water.
- Large-Small organizations combined have a huge difference in water intake, so there is a need to standardize profits.

Based on these conglomerate quandaries, this research tokenizes WRC using cryptocontracts from ether. WRC is the token minted from ether. Any token created from ether using ERC20 mandates a token price. Token price is the price of token exchange for minting coins, while minting ether into WRC tokens.

So, while trying to convert 1 ether into WRC coins, the token price is taken to be 14th power of 10. Minting 10000 WRC coins for one Ether.

$$T_p = 100000000000000 \text{ Wei}$$

$$T_s = \text{WRC}$$

$$T_n = \text{wastewater Reprocessing Coins}$$

where T_p is the token price, T_s is the token symbol, T_n is the token name.

Organizations exchanging coins by minting and withdrawing WRC standardizes trade in the business network. The problem case mentions a profit formula that issues this WRC as quality credits for reusing wastewater. Regulator or the local government benchmark for issuing these

tokens is the regulator set ground zero, minimum percentage reuse of recycled wastewater.

The regulator set ground zero is the arbitrator of quality credits. Such qualified organizations contribute to the maximum supply of coins and trade tokens amidst the organizations that fail to meet the quality benchmark.

For the quality benchmark to be set, the benchmark must be decided by auditing data of water quality acquired from the treatment plants. The data readings are received every hour with lead acid battery backups to restrain it from losing contact with the server because of major challenges while storing data is the problem of data tampering. It is very important for the IOT sensors to stay in contact with the server for reading data; this data are gathered in the database, and the percentage reuse is calculated based on this hourly received data. The percent reuse determines the quality credits earned.

The break in data readings is the fact behind data tampering resulting in heavy penalties or no issued coins for the month. In this way, efficient monitoring of water quality along with data tampering is accompanied by earning tokens. The user interface provides the percentage to the cryptocontract where the transactions are defined.

The profit formula varies according to the proportion of varying organizations above and below the ground zero. Percentage reuse standardizes the phenomenon of equal competence and acquisition of quality credits, which helps big large firms with the annual dependency of several thousand gallons of water trade with SME's (Small Medium Enterprises) requiring only a few gallons of water intake.

For instance: Given a set of sample data to elucidate the profit formula.

Organization 1: This is a chemical industry that requires 25,000 gallons of freshwater, emits 10,000 gallons of wastewater and reuses 6000 gallons after recycling the water that has met the quality standards.

The percentage reuse of this Chemical Industry sums up to an approximate of 60%.

Organization 2: This is a leather industry that requires 8000 gallons of freshwater, emits 2000 gallons of wastewater and reuses 800 gallons of water after recycling the water that has met the quality standards.

The percentage reuse of this Leather Industry sums up to an approximate of 40%.

Organization 3: This is pharmaceutical industry that requires 2000 gallons of freshwater, emits 800 gallons of wastewater and reuses 300 gallons of water after recycling the water that has met the quality standards.

The percentage reuse of this Pharmaceutical Industry sums up to an approximate of 37.5%.

The above statistics bolster the fact that,

- any type of corporate sector depending upon freshwater and
- any firm of large/small/medium scale

contribute equal opportunity of fair trade in the business network.

The water quality monitoring is examined in the database and for the organization fitting into those quality checks the regulator either issues monthly exchange of WRC or receives a token amount of penalty. Internet of Things administers water quality using sensors. Sensors record the data to check it in the realm reach of normal water quality; the UI connects to the blockchain node and the frontend to the database. Some common sensors used in this perspective are:

- Turbidity sensor
- BOD—biochemical oxygen demand sensor
- PH sensor
- Volume sensor
- Temperature sensor
- TDS—total dissolved solids sensor

There is a detailed reason behind using individual sensors over multi-sensor water quality sensing appliances like YSI ProDSS/Pro 20, H198193, Proteus, etc.

1. The cost and maintenance of a multi-sensor are comparatively higher than installing individual sensors.
2. The range of individual water quality-testing sensors is higher than a multi-sensor.
3. Every individual sensor is dependent on one another. If one stops working others cannot function; to repair the faulty sensor even the other sensors can't be used for sensing to record hourly data.

The mechanism of IOT sensing is that on any physical change received during the working of the entire model, the sensor is calibrated to detect and send the digital/analog signal to the central unit, i.e., IC ESP32, which in turn further connects to the webserver using wifi chip and updates the data result at the unit interval of time.

What concerns the regulating of participant organizations is the fluctuation around regulator set at ground zero,

Enforcement of %reuse

the arrival of an organization B below ground zero

and the arrival of organization C above the ground zero.

This fluctuation is the bottom layer architecture of the cryptostocks, this architecture determines the present value of the token price. Understanding profits comes with the count of organizations.

The profit gain formula can be considered as a ratio as follows:

let P_r be the *Profit Ratio* given as under,

$$P_r = O_a / (U_a + O_a)$$

given $P_r > 50\%$

where O_a is the grouping count of over-achieving organizations, U_a is the grouping count of under-achieving organizations.

Loss ratio: This damage is equivalent to the above profit ratio extending in one criterion.

$$P_r = L_r$$

where $P_r < 50\%$

So,

$$L_r = O_a / (U_a + O_a),$$

$$L_r < 50\%$$

The deviations in the above ratio are linked to the cryptostock. WRC is a token on ERC20; therefore, this token corresponds to a token price. The regulator defines the token price as a firm value standardized by the value corresponding to the ground zero percentage ratio.

Let S_p be the stock price,

S_p has a constant value at ground zero equivalent to T_p , when the P_r ratio is equivalent to 50%

$$S_p = T_p \pm P_r$$

where P_r is $>$ or $<$ 50%, when $P_r < 50\%$ then $P_r = L_r$.

For instance:

Organization B in the bar graph is counted as an underachiever with a percentage reuse of 20%; similarly, organization C is counted as overachiever with the percentage reuse of 60%. assuming this data the stock price won't be affected by P_r as

$$O_a = 1$$

$$U_a = 1$$

$$P_r = O_a / (U_a + O_a)$$

$$= 1/2 \text{ i.e. } 50\%$$

Note: The above formula for calculating S_p is valid only when P_r is not equal to 50%, i.e., $P_r \neq 50\%$

The issuing of quality credits in tokens will be provided to the respective groups (O_a or U_a) depending upon the percentage reuse calculated.

The application of IOT sensor in the wastewater monitoring integration involves an analysis of the water quality standard for normal wastewater after treatment. The

volumetric analysis is done before and after the treatment of wastewater. The conformity of the percentage reuse of wastewater in the issuing of tokens is in regard to this set of gathered readings from each of the participant enterprises. Enterprises in the business network earn quality token credits, based on this endorsement ratio. The set of gathered readings from each of the sensors is required to pass a quality probe in every unit time. The concluding volumetric analysis is the average of those volumetric readings that pass the quality check during the entire month in every standard unit of time intervals.

Percentage reuse is given by

The ratio of volumetric analysis before and after the treatment of wastewater.

Let R_e be the required ratio.

$$R_e = (V / V_A) * 100$$

where V volume of wastewater, V_A volume after treatment, V_A is the average of those readings that pass the quality probe given the sample table to elucidate the sensing process.

$$V_A = \Sigma(\text{volume analyzed with acceptable quality}) / n$$

where n is the No. of times the quality was maintained out of the total no. of readings (N) taken, such that $n > N/2$, i.e., 50%.

S. no.	Turbidity sensor	PH sensor	Temperature sensor	BOD sensor	COD sensor	TDS sensor	Oil sensor	Volume	Result
1	✓	✗	✓	✗	✗	✓	✗	V_a	Fail
2	✓	✓	✗	✓	✓	✓	✓	V_b	Pass
3	✓	✓	✓	✓	✓	✓	✓	V_c	Pass

An overview glimpse of the deployment of IOT sensors in the business model to test the water quality probe and the application of IOT sensing can be taken into consideration by the following the diagram; the feature of esp32 microcontroller is that it can be programmed with wifi and bluetooth. For obtaining digital signal output to the analog sensor, we use an ADC converter, IOT meter port to connect our sensors: turbidity, ph, temperature, etc. Triac T1 BT138-V for output pulse modulation. IC2 7805T for voltage regulation.

4 Limitations

- The token is built on ERC20 which means its dependency on ether prohibiting full user access.
- The cost of ethereum nodes mining the blocks vary according to demand and supply; this indirectly affects the minting of the tokens at varying prices according to Ether.
- The token price fluctuation is explicitly elucidated, but P_r is not the only deciding factor affecting S_p . So token price is not completely determined by factors inside the business network.
- The cost associated with the setting up of IOT sensors for a large number of organizations might be huge. This involves a large amount of capital invested for IOT sensors; these sensors are then fitted in the pipe holes and openings to record and monitor the task it is calibrated to perform.
- After huge capital investment, the IOT sensors also include the cost of maintenance; setup cost is not the prerequisite alone. To attain the desired set of efficient results and accurately measure data, the IOT sensors need a different budget for its maintenance. The architecture after set up needs to be periodically inspected and checked, any requirement regarding waste accumulation around the sensors has to be dealt with the immediate action, so that the recording of data doesn't get affected and business network prolongates to serve the fair trade.
- PH sensors used in sensing might not efficiently record data as it was expected to after 2–3 months because of the accumulation of layers of embedded salt around it. This problem can only be either replacing the IOT sensor or ensuring regular inspection and cleaning around the sensor body.

- The organization where the sensors are deployed needs to have a continual internet network to stay connected to the server while reading the data.
- The research does not implement or provide a solution to the cross border challenges for business in countries with varying legal regulations and degree of acceptance for tokenizing blockchain economy [32].

5 Conclusion

With any observed physical change using the IoT sensors, the record of our data maintaining the water quality gets amended with the server. This eventually is directly concerned with the marking of standards in the growth statistics of each of the business organizations, composing a part of the network. The contribution of quality credits is merchandising blockchain for business on a protuberant scale. Encrypting the identities of organizations by the cryptographic hash of the account address in ethereum manifests security. This research on ethereum blockchain coalesce trade is rooting on sustainable assets like wastewater. A private network on ethereum provides limited record of transactions happening only within the network. Our readings put in proportion the percent endorsement of reuse from the regulator set ground zero. The tokens are issued based upon this proportion, i.e., the percentage reuse of wastewater, featuring the highlighted part of this research alongside the factors affecting T_p . What needs a careful thought is the prominence of the profits for the use cases that involve organizational trade.

After the successful completion of this research, we pen down the holistic reported results. We validate our business logic deployed on a permissioned ethereum network on the POA consensus.

Using the quality benchmark of 35%, we establish the relationship and dependency of two important token parameters, i.e., S_p and T_p in the business network.

According to the current business logic, all the organizations can mint and withdraw tokens; however, the purpose of research was to implement this innovation to build smart cities, so as per real-time deployment challenges and for better administration over decentralization, the business logic is expected to concede with the regulator's consent for minting tokens from ethers at the organizational level of deployment.

Future works are on 2D/3D data visualization on the IOT meter data clusters to minimize the probability of tampering; however, these real times challenges are not a hinderance to the research at this level. A proportion of each organization's profit with the volumetric dependency on fresh water, after successful reuse of treated water is another fact into consideration.

Further research might consider the use of Zigbee and 6LoWPAN protocol for connectivity and information transfer between the IOT sensors for featuring automation in this corporate taxonomy. ECP32 is just demonstrating an overview of the sensing application, a strong determining factor of the incorporate future changes will occur according to the location of deployment.

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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