A BLOCKCHAIN-BASED IOT-ENABLED E-WASTE TRACKING AND TRACING SYSTEM FOR SMART CITIES

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ABSTRACT

Recycling of electronic waste is a rapidly growing global issue that requires proper monitoring and tracing of electronic devices and the business transactions between the stakeholders. The majority of current systems that manage electronic devices throughout their supply chain stages are centralized and lack data transparency, immutability, and security In this paper, we propose a blockchain based IoT-enabled system for monitoring all post-production business processes, activities, and operations performed on an electronic device. The system is supported by smart contracts that record the actions of users on the immutable distributed ledger that aid in ensuring that the business processes carried out by the participants are transparent, traceable, and secure. The proposed system is tested on Ethereum blockchain to check the gas consumption of the functions of the smart contracts. The cost and security analysis shows that the proposed system is viable.

Keywords: IoT, Ethereum Blockchain, Recycle, E-Waste

I INTRODUCTION

Smart cities rely on multiple technologies to create, deploy, and promote sustainable development strategies to meet the increasing demands of urbanization. For smart cities to be sustainable, they try to be energy efficient and have a small carbon footprint. In order to improve quality of life, the Smart City Index (SCI)

examines many factors, such as health, mobility, safety, and waste management. Population growth, urbanization, and economic growth have all led to a rise in waste generation. Considering the impact of waste on public health, environment, and climate, modern waste disposal and treatment methods, such as bioremediation, incineration, and plasma gasification, are utilized. In the last two decades, the life span of electronics equipment has reduced substantially due to rapid technical advancements. Managing e-waste is currently one of the major challenges of the urban cities. E-waste is more difficult to manage than conventional waste since it contains toxic chemicals, radioactive materials, and storage devices that might lead to privacy and security issues. If the storage devices are not disposed appropriately, they may fall into the hands of adversaries who acquire storage devices in bulk and scan them for sensitive information. Some of these solutions also offer financial incentives in the form of tokens to motivate people to deposit waste in the designated places. Due to the absence of auditing features, there is always a risk that e-waste may enter the black market, where criminals can extract radioactive materials or confidential data from the storage devices. Moreover, these systems are typically centralized and have scalability and single point of failure issues. Moreover, these solutions often lack essential features, such as transparency, traceability, accountability, and privacy etc. Considering the issues of the centralized solutions, researchers have emphasized the usage of blockchain-based solutions for numerous applications including waste management. Hence, along with the centralized solutions, there also exist some blockchain based solutions for the waste management. However, these solutions are mainly designed for medical waste or general waste management. There also exist some blockchain based solutions proposed for smartphones and electronic devices, however, they focus on a particular portion of the forward supply chain

These solutions lack many important features, such as tracking and tracing from the time of manufacturing to the time of recycling, validation of the involved stake holders and their license status, reputation management of the stack holders, and

issuance of certificates confirming the destruction of storage devices. In this paper, we present a blockchain based IoTenabled e-waste tracking and tracing system.

II LITERATURE REVIEW

When it comes to waste management, smart cities are increasingly focusing on the design and development of waste management solutions that are based on advance technologies, such as Internet of Things (IoT), Cloud Computing, AI and blockchain. There are various solutions for waste management in which the consumers or stakeholders are given incentives for recyclable goods. For example, in and the consumers are rewarded coins/tokens for depositing their recyclable goods. In the researchers highlight some of advantages of the blockchain technology and the main challenges in adopting blockchain based waste management systems. In the researchers present a blockchain based reward system for solid waste management. In this system, LoRa based sensors are attached to waste-bins to monitor the garbage level. This data is uploaded to the cloud on runtime and also written on the blockchain. The individuals who dispose their waste in the bins are automatically rewarded based on the quantity of the waste. this work, there are no special considerations for the e-waste. In the researchers present a smart trash control system for universities to reduce cost of waste collection. Similar to the previous technique, they use multiple LoRa based sensors to monitor the garbage level in the waste-bins. In addition, they use ML technique to predict the time of the waste-bins and graph theory-based optimization solution to compute paths and schedule for waste collection. Similar to the previous work, there are no special considerations for the-waste.

In the researchers present a blockchain-based solution for COVID-19 medical equipment waste management. This system uses Ethereum blockchain with Interplanetary File System (IPFS) for the management of COVID-19 medical equipment data. The positive aspect of this system is that the interaction rules for

the management and handling of COVID-19 waste are denied. In addition, relevant entities are penalized for violations in case of mishandling of the medical waste. This work only deals with the COVID-19 waste and has no special considerations for the e-waste. In the researchers present a smart waste management system that uses pricing estimation model to charge waste producers based on the quantity of the waste that they produce. This system utilizes IoT for monitoring waste in the waste-bins.

III EXISTING SYSTEM

The researchers present a distributed trust less solution for reverse logistics activities related to e-equipment, especially the smartphones. The main contribution of this work is the use of blockchain for smartphone refurbishment, with a particular emphasis on the privacy of user data kept on the devices, in order to increase consumer confidence in refurbished smartphones. This solution has no bidding mechanism and does not provide certificate for destruction of data that is stored on the electronic devices. Existing research has ignored the role of the data destruction unit in e-waste management, putting data security at risk. In addition, the participants' reputation scores were not considered in the aforementioned works. As a result, participating entities may engage in unethical activities, and electronic device and e-waste trading frauds may occur. To prevent such frauds, in our proposed system, only participants with impeccable reputations are permitted to trade electronic devices and their waste.

IV DISADVANTAGES

1. High Initial Costs
2. Scalability Challenges

3. Energy Consumption

V PROPOSED METHODOLOGY

The smart contracts are written, compiled, and tested in the Remix IDE for system evaluation. We designed multiple smart contracts, namely Registration, Order Manager, Waste Manager, Bid & Reputation Manager, and Data Destruction Manager to implement services relevant to operations performed on the electronic products by the stakeholders; after they are manufactured. Electronic device manufacturers manufacture a large number of electronic gadgets, which they then publish on the blockchain. Important details about the created lot are published on the blockchain, which includes total quantity, price, and minimum and maximum order thresholds information

VI BLOCK DIAGRAM

These diagrams show the function calls and events that occur on the blockchain when a function is called. Diagram shows a sequence diagram that highlights the user's interaction with the system. All system users must be registered on the blockchain and must have valid licenses in order to transact on the blockchain. The presented sequence diagram shows the business operations carried out by the Order Manager smart contract. Order manager smart contract allows participants to place, reject, deny, and accept requests of buying or selling the electronic devices or waste. This smart contract is deployed on the blockchain by the manufacturer. The manufacturer registers information about the manufactured electronic devices on the blockchain, as well as, their images on IPFS. Retailer places a purchase order request using Order Manager smart contract to show the willingness in purchasing the electronic equipment.

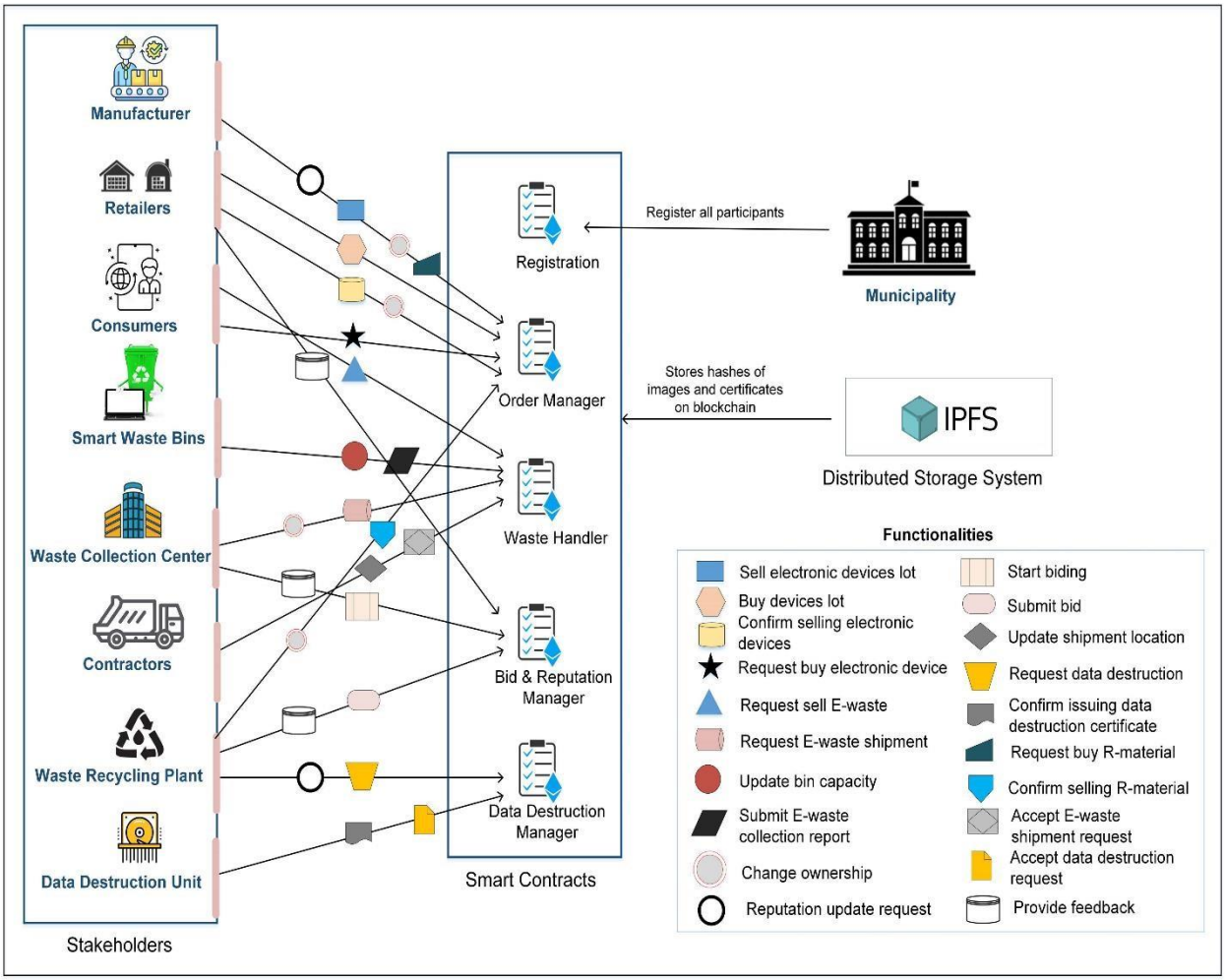

Figure 1 block chian

VII ADVANTAGES

1. Enhanced Transparency and Traceability
2. Improved Efficiency in Waste Management
3. Data Integrity and Security
4. Promotes Circular Economy
5. Regulatory Compliance
6. Cost Reduction Over Time
7. Integration with Smart City Ecosystems
8. Increased Stakeholder Trust and Engagement

9. Real-Time Insights for Decision-Making
10. Environmental Benefits
11. Supports Extended Producer Responsibility (EPR)
12. Encourages Behavioural Change

VIII APPLICATION

E-Waste Collection and Sorting -Smart Bins: IoT-enabled bins equipped with sensors can monitor fill levels, identify e-waste types, and optimize collection routes. Automatic Logging: Blockchain records each waste item at the point of disposal, creating a traceable chain of custody. Tracking E-Waste Lifecycle Product Origin to End-of-Life: Track electronic items from manufacturing, usage, disposal, and recycling, ensuring compliance with regulations. Ownership Transfer: Ensure clear ownership records for accountability in waste disposal and recycling. Regulatory Compliance and Reporting Simplified Documentation: Provide immutable proof of compliance with government e-waste management regulations. Audit Trails: Offer authorities a transparent system to verify e-waste handling and recycling processes. Recycling Process Optimization Material Recovery: Track valuable materials in e-waste (e.g., rare earth metals) to ensure recovery and reuse. Process Automation: Smart contracts can trigger automated payments and updates when waste reaches recycling facilities. Incentive Programs
Tokenization for Recycling: Reward consumers and businesses for proper e-waste disposal using blockchain-based tokens. Behavioural Change: Encourage recycling by gamifying the disposal process, offering real-time feedback and rewards.

IX RESULT AND CONCLUSION

In this research, we presented an IoT-enabled block chain based system for tracking and tracing of electrical devices and their waste. Using the Ethereum blockchain-platform, we designed a system that enables stakeholders to perform their business processes in a completely decentralized, secure, transparent, and auditable manner. The proposed system enables the authorities to ensure that electronic devices are purchased and supplied from licensed, reputed, and trustworthy users, disposed of appropriately, and managed by the participants in a safe and privacy-preserving manner. We resolved the scalability issues of the existing blockchain solutions by storing big data sets pertaining to electronic devices, e-waste, and participants on the IPFS server. Moreover, we conducted the cost and security analysis of the proposed solution and found that our solution is practical, secure, viable, and highly dependable. The proposed system is generic and with small iterations it can be implemented for various other use case scenarios, such as domestic waste management, water waste management and other scenarios where traceability is required. In the future, we aim to incorporate additional types of waste into our system, such as wastewater, organic wastes, and food waste. Moreover, we will propose a mechanism for rewarding consumers for the deposited electronic devices.

IX FUTURE SCOPE

The future scope of a blockchain-based IoT-enabled e-waste tracking and tracing system is vast, given its potential to revolutionize e-waste management and align with global sustainability goals.

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