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E-Waste Management System using Blockchain

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***Abstract*— We have become too dependent on technology owing to which the quantity of e-waste produced has increased at a rapid pace. On having known the growing amount of e-waste, the possibilities of these non-biodegradable elements contaminating the atmosphere are towering. To overcome this challenge, a blockchain-based e-waste management technique is proposed. The solution proposed in the paper tracks the e-waste produced and motivates people by providing them incentives for channelizing the e-waste via government agencies that dispose of the waste in an environment-friendly way. Henceforth, a partnership model is proposed for the implementation of this method which leads to a tremendous amount of increase in jobs, but not only limited to that, it also provides the proper organization of unplanned setup that is with a huge amount of prospective potential.**

Keywords – E-waste, Blockchain.

I. INTRODUCTION

Human beings produce electronic waste at an unprecedented pace. Until 2016, the world produced 44.7 million metric tonnes (Mt) of e-waste, and only 20% of this tonnage found its way through proper recycling channels. The quantity of e-waste is expected to reach up to 52.2 Mt by 2021. India introduced its first set of e-waste management laws in 2011 which were further amended in 2016 and 2018. The responsibility of collection and channelization of e-waste has been given to the producers, manufacturers, and dealers of Electronic and Electrical Equipments. Authorization to these stakeholders is given only if they meet their phase-wise collection targets of e-waste.

E-waste management is the process of discarding e-waste in an environmentally friendly way. The first and foremost step is the collection of e-waste items from the consumers, which is followed by sorting those into reusable and non-reusable products. The products that can be reused are kept for re-sale while the non-reusable products are disassembled. The non-reusable dismantled parts go through multiple rounds of shredding and separation. They are either recycled to be used again as new, or they are safely disposed of after proper treatment of hazardous components.

The greatest problem in terms of the Management of e-waste is the tracking of the movement of e-waste. Most of the time, people are not worried about the growing environmental problems or are simply not aware. At other times, they may think that it is a hassle to go towards proper e-waste disposal centers as they are not directly getting anything from it (ignorant, yes). One solution we could have for this is by having the waste tracked via supply chains under a blockchain and then rewarding the honest and responsible people with tokens that can be used to earn discounts or simply buy other products.

For this, we will need to have a partner company/organization that would be willing to provide discounts/offers in exchange for our tokens. What we can do is we can offer those e-waste products back to the companies for recycling. However, products often have a specific warranty duration or... peak/usable lifetime. Beyond that, products may get faulty. On basis of that duration and beyond, if the product is returned, it can provide a chance for discounts, etc Another situation that could be thought of as a problem by some is that people may try to misuse the blockchain like stealing products from someone else, perform counterfeit or... double-spending, etc.

These problems can be easily taken care of if we assign the affiliated company to register and store within their database to who they've provided the product (which is very often done in megastores like chroma) This eradicates the problem of stealing and counterfeit. As for double-spending, we can deal with that using the carrot and stick method of crypto-economics. It's simple, the problems are solved.

II. LITERATURE REVIEW

The increase in digitization has brought a rise in the amount of e-waste generated throughout the world. This growing trend in the volume of e-waste produced worldwide has been captured. A detailed review of different kinds of treatments followed for disposing of e-waste in an environment-friendly manner has been defined in [1]. It highlights step-wise procedures for

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collection, segregation, disassembly, and treatment of electronic waste. India, in particular, also needs to handle its domestic e-waste (generated within the country) as well as imported e-waste (dumped into India). An assessment of e-waste management policies and recycling practices within India has been discussed in [2]. In the paper, the effects of untreated e-waste on the environment have been highlighted. Major barriers in the implementation of policies for proper disposal of generated electronic waste have been mentioned in [3]. To the best of our knowledge, the majority of research in the field of e-waste focuses either on the processing steps involved in EWM or on the harmful effects of improper disposal of EEEs.

The concept of blockchain, through Bitcoin, was introduced by Satoshi Nakamoto. The working of blockchain along with the details of privacy, anonymity, and security, has also been mentioned. Various applications of blockchain are described in [4]. The details of the working of the Ethereum blockchain have been described. Some research directions for blockchain data management have been mentioned in [5]. As per our research in India, the approach to tackle e-waste using blockchain-based smart contracts has not been put forward as a proposal in any existing research work. In this paper, we present a novel approach to EWM in India using smart contracts to regularize the process.

III. EXPERIMENTAL SETUP

The following modules of smart contracts, as shown in Figure 1, will be included in the blockchain network:

3.1 Authorization Module

This module of the smart contract will be used exclusively by GAs to provide a digital e-waste license to any PR, RT, and owner of CC or RU, allowing them to start their operation in India. This license will state each stakeholder's responsibilities in terms of their e-waste collection targets for upcoming years and the penalty for not meeting the specified target. If the stakeholders fail to meet these targets, the penalty amount, as calculated by the smart contract, will be automatically deducted from the stakeholder's account and transferred to the appropriate government account.

3.2 Producer Module

This module will call the Collection Module to verify the contribution of e-waste made by Producers. Once verified, the Producer module will calculate the remaining amount of e-waste that must be gathered by the Producers to meet their upcoming collection target. If Producers lag behind in their contribution, automated reminders will be sent to them by this module of the smart contract, on behalf of Government Agencies.

3.3 ExchangePR RT Module

This module will monitor the exchange of EEEs between PRs and RTs. At the time of purchase, a transaction must be initiated by the RT. This transaction must specify the PR's e-waste license number, the RT's e-waste license number and the record of the units exchanged between them. The module will access this transaction data to verify that each PR's specified Supply Amount (specified in Producer Module) matches the total amount of EEEs that he/she has exchanged with different RTs. In case of a mismatch, the module will reject the transaction and penalize the corresponding PR for his/her malpractice.

3.4 Retailer Module

Each RT must record the amount of EEEs that have been purchased by them (Purchase Amount). This amount will be verified through the ExchangePR RT Module. RTs must also specify the amount of e-waste they have gathered so far, its source, and the PRs on the EWMB from whom they will purchase. The Retailer Module will call the Producer Module to verify the contribution of e-waste made by RTs and whether the PRs specified by RTs match with the list provided by the PRs.

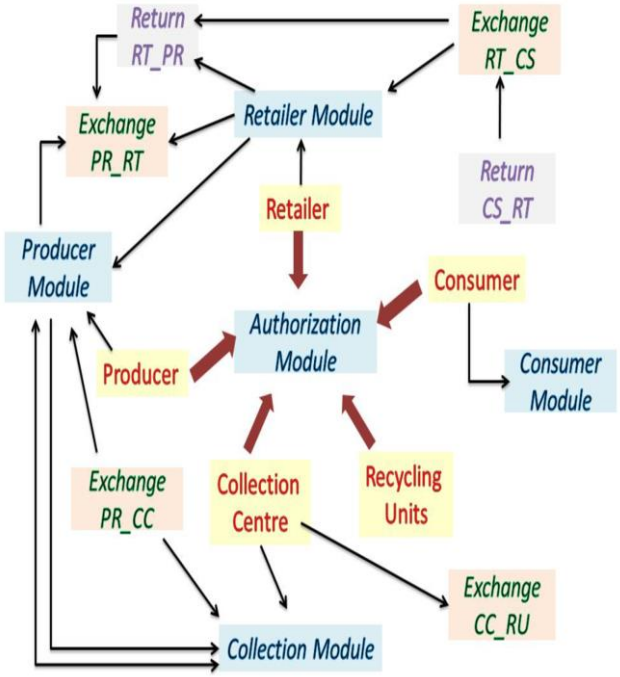

Fig.1 An illustration of the smart contracts and different stakeholders in the EWM.

3.5 ExchangeRT CS Module

This module will monitor the exchange of EEEs between RTs and CSs. It works like Ex- changePR RT Module, but the transaction must be initiated by CS. This transaction will specify RT's e-waste license number, the CS's Aadhar number and the record of the units exchanged between them. RT's Purchase Amount will be verified using the Retailer Module by examining all transactions with respect to each RT.

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3.6 Consumer Module

CSs who wish to join the EWMB must call this module to register themselves through their unique identification number like Aadhar.

3.7 ReturnCS RT Module

CSs invoke this module when they want to return their EEEs that have reached their end of life. The details of the discarded EEEs are provided in this module. The ExchangeRT CS Module is invoked to find the RT to whom this e-waste belongs. An alert is automatically sent to the RT specifying the CS details and the deadline to collect the e-waste. When RT collects the e-waste from the CS, a percentage of the product's original cost is credited to the CS account automatically. If the deadline is not met, the penalty amount (pre-defined in the module) is debited from the RT's account.

3.8 ReturnRT PR Module

RTs call this module when they want to return their collected e-waste to the PR from which the discarded EEE was brought. The ExchangePR RT Module is called to find the PR responsible to collect this e-waste. An alert is sent to the PR with RT details and the deadline. When the PR picks up the e-waste from the RT, the Retailer Module is called to update the RT's remaining collection amount. If the PR fails to meet the deadline, the penalty amount (pre-defined in the module) is debited from the PR's account.

3.9 Collection Module

This module is used by CC owners to authorize themselves on EWMB through GAs. These CCs are provided with a unique e-waste collection license. This license bounds them to accept e-waste as per their collection capacity and deliver it only to authorized RU. CCs must provide a list of PRs from whom they will accept e-waste. The Collection Module verifies this information by invoking the Producer Module. CCs also record the amount of e-waste they have received from various PRs.

3.10 ExchangePR CC Module

The PRs will invoke this module when they are ready to transport their collected e-waste to the CC. When CC accepted a certain amount of e-waste, the PR's remaining e-waste value is updated in the Producer Module. The Collection Module is also invoked and the information about the amount of e-waste deposited at the CC is updated.

3.11 ExchangeCC RU Module

The e-waste collected by CCs is transported to the authorized RUs.

3.12 Self Life Module

All the electrical and electronic equipment that are bought by the consumers will have a self-life. A self-life is defined as the time period for which the device or equipment is covered under a guarantee/warrantee period or the period for which it is more likely supposed to work properly. The self-life for a piece of equipment will be given by the manufacturer itself. After the self-life of equipment is over, consumers will have to renew their self-life, if it is in working condition, or discard it as e-waste through the blockchain network, if it is not working properly. The self-life can be renewed only through an expert such as the service centers.

The following technology stacks will be used in the development of the project:

- Ethereum Blockchain:

  Ethereum is a distributed, open-source blockchain network with smart contract functionality

- JavaScript, HTML, CSS

  Used to form the user interface

- Solidity:

  The programming language used to write the back end code

- Remix IDE:

  The platform used to test, compile and deploy the backend code

- Node.js:

  The platform acts as an open-source, cross-platform, back-end JavaScript run-time environment that runs on a V8 engine and executes JavaScript code outside a web browser

- Web3.js:

  A collection of libraries that will make our lives easier while coding/developing the blockchain

IV. PROPOSED SYSTEM

The project aims at developing an E-waste management system using Blockchain-based Smart Contracts. The goal is to bring together the government agencies, consumers, and stakeholders on the same blockchain platform which will lead to improved monitoring and higher transparency in the process as shown in Figure 2. We also aim to provide a methodology on how we can slowly shift to the blockchain network.

We present a way to improve the situation of EWM in India. Our technique is based on smart contracts, developed using blockchain technology. Having the government agencies, consumers, and stakeholders on the same platform of blockchain will lead to better and improved monitoring and much more transparency in the process. Blockchain will enable proper book-keeping of the Electronic Gadgets introduced in the market by different producers and retailers. This will help the smart contracts to clearly specify collection targets and put a penalty on the appropriate party whenever required. We also propose the inclusion of customers as

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members of this blockchain. Providing incentives to consumers when they dispose of their e-waste to the formal supply chain, can serve as an important step in reducing the supremacy of the unorganized sector in EWM. We have also put in collection centers and recycling units in our proposal. Smart contracts will help in regulating the source and amount of e-waste that has been collected, transported, and recycled throughout the entire process.

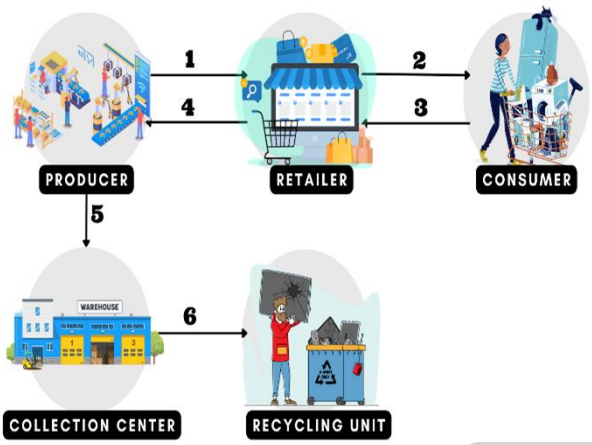

Fig.2. (1) Producer supplies newly manufactured EEEs to the Retailer (2) Retailer sells these EEEs to Consumer (3) Consumer returns their e-waste to Retailer (4) Retailer returns the collected e-waste to Producer (5) Producer delivers collected e-waste to Collection Centre (6) Collection centre transports e-waste to the Recycler for recycling.

In the proposed solution, we use the Ethereum blockchain platform to carry out the EWM in India. The node representing GAs will be responsible for creating the smart contract for regulating the flow of e-waste across various stakeholders and CSs. GAs will authorize only those PRs and RTs who will join this e-waste management blockchain (EWMB). Owners of CCs and RUs, who wish to establish their businesses in India, must also become a part of this EWMB. CSs will benefit from this system by receiving pre-defined incentives for channelizing their e-waste to proper stakeholders present on the blockchain. The smart contract created by GAs will consist of the following modules that will track the activities of each stakeholder/participant.

V. CONCLUSION AND FUTURE SCOPE

Now, there are a bunch of things that we can do with this idea, some are included in the contents above, like the offering of discounts, etc. The basic idea is that it can be implemented throughout the world. In the growing age of technology, e-waste will be increasing, hence a widespread adaptation will be key. It also provides jobs as a validator to multiple people within the industry, not necessarily having knowledge of the blockchain, but can be trained for its utilization.

E-waste contains toxic materials that are dangerous to the environment and human health, such as lead, mercury, cadmium, barium, polybrominated flame retardants, and lithium. These negative health effects on human beings include liver, brain, kidney, heart, and skeletal system damage. When e-waste is exposed to heat, toxic chemicals are released into the air damaging the atmosphere; this is one of the biggest environmental impacts of e-waste. Those toxic substances can then flow into the groundwater, affecting land as well as sea animals.

Electronic waste can also contribute to air pollution. This blockchain-based e-waste management system can be extended to include parts of EEEs like printer cartridges, toners, mobile batteries, chargers, and printed circuit boards used in repairing EEEs. Electronic and electrical parts like these are manufactured and sold in larger quantities than some EEEs and form a significant volume of generated e-waste.

The inclusion of refurbishers will regulate the amount of e-waste that is being reused after the technical renovation of the discarded devices. This will result in accurate estimates of the collection targets apart from the e-waste that has been refurbished. When transporters also become a part of this system, we can easily monitor how the collected e-waste is being transported between different parties. Our future work will involve the complete implementation of the presented system. We also plan to use IoT devices like smart sensors attached to transport devices that will be used to carry e-waste. This is important to prevent any leakage of e-waste into the informal sector. The development of smart barcodes for EEEs and their parts is also included in our future vision. These barcodes when scanned using the decentralized application, will provide the details of the electronic gadget.

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