A Project Report on

E-Waste Management System using Blockchain

Submitted in partial fulfillment of the requirements for the award
of the degree of

Bachelor of Engineering

in

Computer Engineering

by

Anuj SS Mishra(18102059)
Ishan Sathe(20502001)

Under the Guidance of

Prof. Archana Kotangale

Department of Computer Engineering
NBA Accredited
A.P. Shah Institute of Technology
G.B.Road,Kasarvadavli, Thane(W), Mumbai-400615
UNIVERSITY OF MUMBAI

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Approval Sheet

This Project Report entitled ***"E-Waste Management System using Blockchain"*** Submitted by ***"Anuj SS Mishra"(18102059), "Ishan Sathe"(20502001)***is approved for the partial fulfillment of the requirenment for the award of the degree of ***Bachelor of Engineering*** in ***Computer Engineering*** from ***University of Mumbai***.

Prof. Archana Kotangale
Guide

Prof. Sachin H Malave
Head Department of Computer Engineering

Place:A.P.Shah Institute of Technology, Thane
Date:

CERTIFICATE

This is to certify that the project entitled ***"E-Waste Management System using Blockchain"*** submitted by ***"Anuj SS Mishra" (18102059),"Ishan Sathe" (20502001)*** for the partial fulfillment of the requirement for award of a degree ***Bachelor of Engineering*** in ***Computer Engineering***,to the University of Mumbai,is a bonafide work carried out during academic year 2020-2021.

Prof. Archana Kotangale
Guide

Prof. Sachin H Malave
Head Department of Computer Engineering

Dr. Uttam D.Kolekar
Principal

External Examiner(s)

1.

2.

Place:A.P.Shah Institute of Technology, Thane
Date:

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Student Name1: Anuj SS Mishra
Student ID1: 18102059

Student Name2: Ishan Sathe
Student ID2: 20502001

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, We have adequately cited and referenced the original sources. We also declare that We have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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(Signature)

_____

(Anuj SS Mishra - 18102059)
(Ishan Sathe - 20502001)

Date:

Abstract

We have become too dependent on technology owing to which the quantity of e-waste produced has increased at a rapid pace. Considering the growing volume 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 proposed solution 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 an increase in jobs as well as proper organization of unplanned setup that is with a large amount of prospective potential.

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List of Abbreviations

Mt: Million Metric Tonnes
EWM: E-Waste Management
GA: Government Agent
CS: Consumer
PR: Producer
RT: Retailer
CC: Collection Center
RU: Recycling Units
EWMB: E-Waste Management Blockchain System
EEE: Electrical and Electronic Equipment

Chapter 1

Introduction

Human beings produce electronic waste at an unprecedented pace. Until 2016, the world generated 44.7 million metric tonnes (Mt) of e-waste, and only 20% of this tonnage found its way through proper recycling channels. This number is expected to increase 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 (EWM) is the process of discarding e-waste in an environmental friendly manner. The first step involves collection of electronic waste items from the consumers, followed by sorting into reusable and non-reusable products. The reusable products are kept for resale 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 off after proper treatment of hazardous components.

Chapter 2

Literature Review

The rise in digitization has led to a rise in the amount of e-waste generated throughout the world [1]. A detailed review of different kinds of treatments followed for disposing of e-waste in an environment-friendly manner has been defined in [2]. India also needs to deal with its domestic e-waste as well as imported e-waste. An assessment of e-waste management policies and recycling practices within India has been discussed in [3]. In [4] 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 [5].

Chapter 3

Project Design

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. We also aim to provide a methodology on how we can slowly shift to the blockchain network.

3.1 Problem Definition

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 reward 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 that 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.

3.2 Proposed System

We present a way to improve the situation of EWM in India. Our technique is based on smart contracts, developed using blockchain technology. Bringing government agencies, consumers and stakeholders on the same blockchain platform will lead to improved monitoring and higher 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 enable smart contracts to clearly specify collection targets and penalize the appropriate party whenever required. We also propose the inclusion of customers as members of this blockchain. Providing incentives to customers when they channelize their e-waste to the formal sector, can serve as the first step in reducing the dominance of the unorganized sector in EWM. We have also included collection centers as well as recycling units in our scheme. Smart contracts will help regulate the source and amount of e-waste collected, transported and recycled throughout the process.

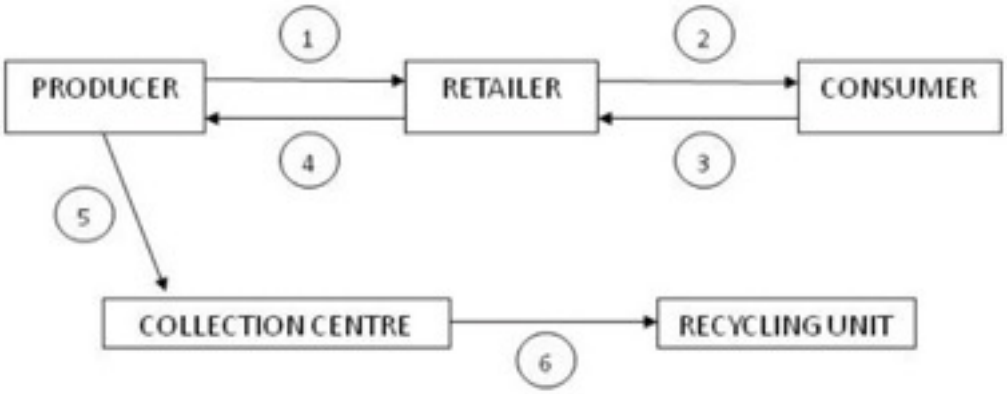

Figure 3.1: Electronics Tracking System

Chapter 4

Project Implementation

In our proposed system, we utilize the Ethereum blockchain to enforce 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 following modules that will track the activities of each stakeholder/participant.

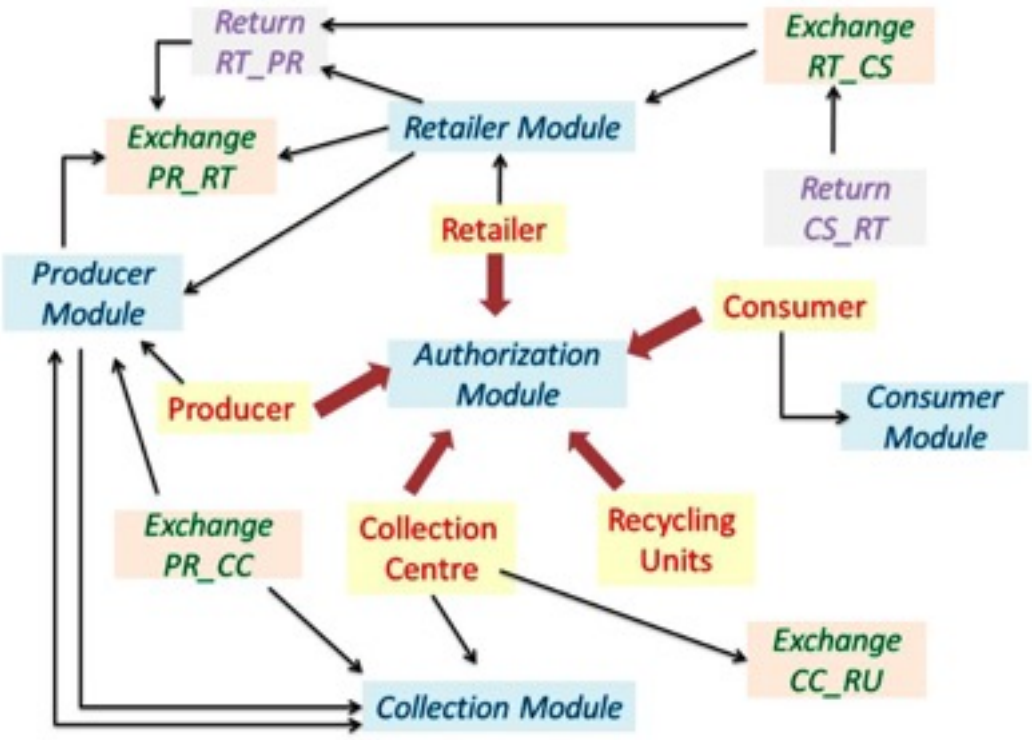

Figure 4.1: Interaction between different modules of smart contracts

4.1 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 appropriate government account.

4.2 Producer Module

This module will call the Collection Module to verify the contribution of e-waste made by Producers. Once verified, 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.

4.3 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.

4.4 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.

4.5 ExchangeRT_CS Module

This module will monitor the exchange of EEEs between RTs and CSs. It works like ExchangePR_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 Retailer Module by examining all transactions with respect to each RT.

4.6 Consumer Module

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

4.7 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 to 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 CS account automatically. If the deadline is not met, penalty amount (pre-defined in the module) is debited from the RT's account.

4.8 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, Retailer Module is called to update the RT's remaining collection amount. If the PR fails to meet the deadline, penalty amount (pre-defined in the module) is debited from the PR's account.

4.9 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.

4.10 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 Producer Module. The Collection Module is also invoked and the information about the amount of e-waste deposited at the CC is updated.

4.11 ExchangeCC_RU Module

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

4.12 Self_Life Module

All the electrical and electronic equipments 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 an equipment will be given by the manufacturer itself. After the self-life of an equipment is over, consumers will have to renew its self-life, if it is in working condition, or discard it as e-waste through blockchain network, if it is not working properly. The self-life can be renewed only through an expert such as the service centers.

Chapter 5

Testing

To guarantee trust, testers must ensure that all the components of a blockchain are working perfectly and that all applications are interacting with it in a trusted manner. Some of the core tests that should be run include functional, performance, API, node testing, and other specialized tests. So here is what they entail in a nutshell:

- Functional testing. This is a holistic process that evaluates the work of various functional parts of the blockchain (e.g. smart contracts).
- API testing. Application Programming Interface tests address the interaction between applications in the blockchain ecosystem. It checks to ensure that API requests and replies are formatted and handled properly.
- Performance testing. It identifies performance bottlenecks, suggests the methods of fine-tuning the system and reviews if the application is ready for launching.
- Node testing. All heterogeneous nodes on the network must be tested independently to ensure smooth cooperation.

In blockchain development, which often follows Agile practices, the shift left approach to testing is gaining popularity. Carrying out a series of tests as early in the development lifecycle as possible allows minimizing the number of defects that could be found in the app's lifecycle later on when the impact on a business can be detrimental.

Chapter 6

Technology Stack

- Ethereum Blockchain:
  Ethereum is a decentralized, open-source blockchain with smart contract functionality

- JavaScript, HTML, CSS
  Used to form the user interface

- Solidity:
  The 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 which acts as an open source, cross-platform, back-end JavaScript runtime environment that runs on 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

Chapter 7

Conclusions 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.

Electronic waste contains toxic components that are dangerous to human health, such as mercury, lead, cadmium, polybrominated flame retardants, barium and lithium. The negative health effects of these toxins on humans include brain, heart, liver, kidney and skeletal system damage. When e-waste is exposed to the heat, toxic chemicals are released into the air damaging the atmosphere; this is one of the biggest environmental impacts of e-waste. Those toxic materials can then seep into the groundwater, affecting both land and 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.

Inclusion of refurbishers will regulate the amount of e-waste that is being reused after 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 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. Development of smart barcodes for EEEs and their parts is also included in our future vision. These barcodes when scanned using decentralized application, will provide the deta

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