



**Department of Computer Science And Engineering**

**System Analysis Design and Development**

**CSE - 402**

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# **Feasibility Report**

**E-waste Management Using Digital Ledger**

**And**

**Cryptographic Transactions**

**Prepared By :**

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## **ABSTRACT SUMMARY**

With the rapid urbanization and continuous economic progress, the dependency on technology are increasing day by day in developing countries like Bangladesh. Thus, the amount of e-waste generated after their life cycle is increasing at an unprecedented pace. Besides, Typical consumer electronics contain a rich amount of chemicals and toxic compounds which can cause environmental and health hazards if they are not disposed properly. In the perspective of Bangladesh, a large percentage of e-waste is not regulated and the disposal process of generated e-waste is quite dissatisfactory. We create too much e-waste and reuse or recycle way too little. To overcome this problem, we have proposed three candidate systems as a blockchain and smart contract-based system, an Enterprise resource planning-based system and an IOT based system here. In this report, each candidate system has been analyzed on the basis of System Characteristics, Qualitative Evaluation Matrix, Performance & Cost Evaluation Matrix and Weighted Evaluation Matrix. With the help of these detailed procedure, we have proposed the best candidate system to solve the problem effectively.

# 1. Introduction

Electronic waste (E-waste) is the fastest growing category of solid hazardous waste. Until 2016, the world generated 44.7 million metric tons of e-waste, and only 20% of this tonnage found its way through proper recycling channels [1]. At present, in every year Bangladesh generates roughly 2.8 million metric tons of e-waste. But without knowing the harmful effect of the e-waste, these has been dumped in to the open landfills, farming land and in the open sources of water bodies. So, it is necessary to introduce a proper e-waste management system. Thus, we have proposed a system to solve this problem taking the appropriate situations in consideration.

## 1.1 Scope:

- The purpose of our system is to create a secured and transparent solution in e-waste management system.
- We have considered that our proposed system is capable of recording every stage of e-waste management and every vital information of every electronic.
- These records cannot be changed or overwritten to ensure the security of the system.
- Also, the system will bring more coordination among producers, importers, retailers and recyclers without the help of any middle man.

## **2. Existing System**

### **2.1 Information Gathering and Analysis**

#### **2.1.1 Overview and Objectives**

In Bangladesh, there is a growing concern of generation of e-waste and its subsequent handling and disposal. E-waste and its reuse and recycling processes can cause significant environmental and health hazards. At present, there is a lack of awareness about the hazards of electronic waste in Bangladesh. The electronic waste is reused, broken down for parts or disposed of completely. The present informal practice of recycling is not carried out safely and it becomes a danger to human health and the surrounding environment. This paper will share the trend of usage of electronic equipment and what is being done at the end of lifetime of the equipment. It will also share what hazards have been created from this electronic waste, what are the present dumping practices and what rules are in place for dumping. It will also identify the level of awareness regarding e-waste and to determine a way to reduce environmental hazards.

### **2.1.2 The Sources of Information**

The aim of this project is to make the e-waste management system in Bangladesh efficient. For this, we gathered some important information about e-waste recycling process in Bangladesh and how to make this existing system more efficient. The sources we chose for our feasibility report are as follows:

- General Users.
- Local E-waste collectors.
- Online articles and research papers.
- Field Visit

We have selected the Source “General Users” to acquire information about general knowledge of people regarding e-waste and their procedure to process domestic e-waste products. We have gathered idea about the security, the processing of e-waste and how to create a proper supply chain from manufacturers, retailers, users and recyclers using blockchain and smart contracts. Finally, we have done a field visit to know about the procedure of collecting e-waste from local e-wastes collection shop (vangari) as well as corporate and public clients and the methods of recycling in Bangladesh.

### 2.1.4 Information Gathering Methodology

To gather the information needed, 3 of 5 traditional methods of information gathering were used. The methods are given below:

1. Questionnaires.
2. Literature review.
3. Interview.

A mapping of the gathered information is shown below:

Method	Source	Information	Outcome
Information Gathered Through Questionnaires. (M1)	General Users (S1)	What idea does general people have electronic waste? (I1)	Most of the people have idea about electronic waste. (O1)
		How do people process domestic e-waste products? (I2)	Most of the people sell their e-waste on second hand. (O2)
		Do people know about the environmental impact of e-waste? (I3)	Most of the users think improper disposal of e-waste is harmful for environment. (O3)
		How to create awareness about proper e-waste disposal among general people? (I4)	Most of the people wants to grow awareness and have education about e-waste. (O4)
		What do general users prefer to do with their e-waste? (I5)	Most people are willing to sell their e-waste product in order to have someone effective dispose it. (O5)

Method	Source	Information	Outcome
Information Gathered through Literature Review (M2)	Research Papers (S2)	How can we make the system secured using blockchain? (I6)	Blockchain can be implemented in e-waste recycling schemes where people can exchange their old gadgets and non-working electronics for digital tokens. (O6)
		Where does the existing systems fail? (I7)	A set of international regulations, including repair, reuse, remanufacture, refurbish, fake/counterfeit product and copyright exhaustion disprove E-waste recyclers. (O7)
		How important is the participation of the manufactures in this whole process? (I8)	To create a proper supply chain from manufacturers, retailers, users and recyclers manufactures plays a big role. (O8)
		Do people know about the environmental impact of e-waste ? (I3)	Most of the people ignore the environmental impact of e-waste. (O9)



Method	Source	Information	Outcome
Information Gathered through Literature Review (M2)	Research Papers (S2)	What conditions need to be set for the smart contacts to operate? (I9)	Co-ordination among producers, importers, retailers and recyclers of EEEs is needed. (O10)
		Can the system be used for illicit activities? If so, how to reduce that? (I10)	Every user can add information to the blockchain and all data in the blockchain is secured through cryptography. (O11)
		What information can be shared with suppliers? (I11)	One of the most prominent capabilities of blockchain technology in this context is to enable transparency and traceability of e-products by storing the entire life-cycle, starting from their origin through every point of contact on the journey. (O12)
		How revenue is generated in e-waste recycling process? (I12)	After purchasing a waste product, recyclers first run a check to see whether the product is functioning or not. (O13)

Method	Source	Information	Outcome
Information Gathered through Literature Review (M2)	Research Papers (S2)	How revenue is generated in e-waste recycling process? (I12)	If a product is functioning they sell it to a purchaser who looks for second hand parts. (O14)
			Sometimes they break the product into pieces to separate iron, lead, copper, silver, plastic etc. and sell this to a purchaser of these things. (O15)
			They sell the raw materials to factories and plants. (O16)
			Those items which are not recyclable in our country are sold to recyclers from overseas. (O17)
Information Gathered through Interview (M3)	Azizu Correspondent ( Local E-waste collector ) (S3)	How are the e-wastes collected from the locality? (I13)	E-wastes are collected from local e-wastes collection shop (vangari) as well as corporate and public clients. (O18)
		How are the e-wastes processed? (I14)	If a product is functioning they sell it to a purchaser who looks for second hand parts. (O14)

Method	Source	Information	Outcome
Information Gathered through Interview (M3)	Azizu Correspondent ( Local E-waste collector ) (S3)	How are the e-wastes processed? (I14)	Sometimes they break the product into pieces to separate iron, lead, copper, silver, plastic etc. and sell this to a purchaser of these things. (O15)
		How revenue is generated in e-waste recycling process? (I12)	Sometimes they break the product into pieces to separate iron, lead, copper, silver, plastic etc. and sell this to a purchaser of these things. (O15)
			They sell the raw materials to factories and plants. (O16)
			Those items which are not recyclable in our country are sold to recyclers from overseas. (O17)

## 2.2 Presenting The Existing System

Most of the activities right from the collection, transportation, segregation, dismantling, etc., are done by unorganized sectors manually. Being a rich source of reusable and precious material, E-waste is also a good source of revenue generation for many people. The big portion (rag pickers) of the population earned their livelihood by collecting and selling the inorganic waste-like plastics, polythene bags, glass bottles, cardboards, paper, other ferrous metals, etc.

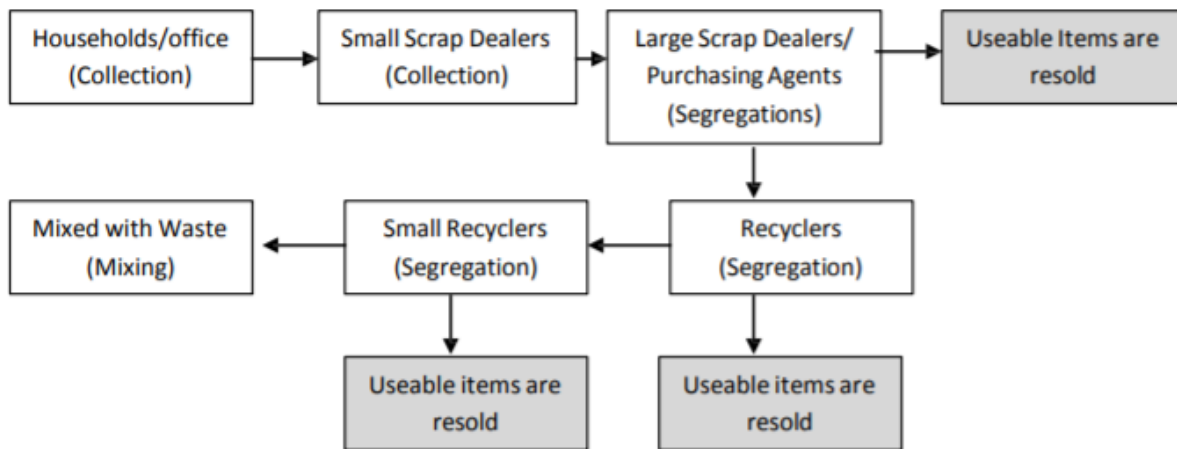


Figure: Flow diagram of existing system.

The following figure shows the road map/trade chain of Electronic and Electrical Equipment's journey from manufacturer/ importer to recycler/disposer found in most of the cities.

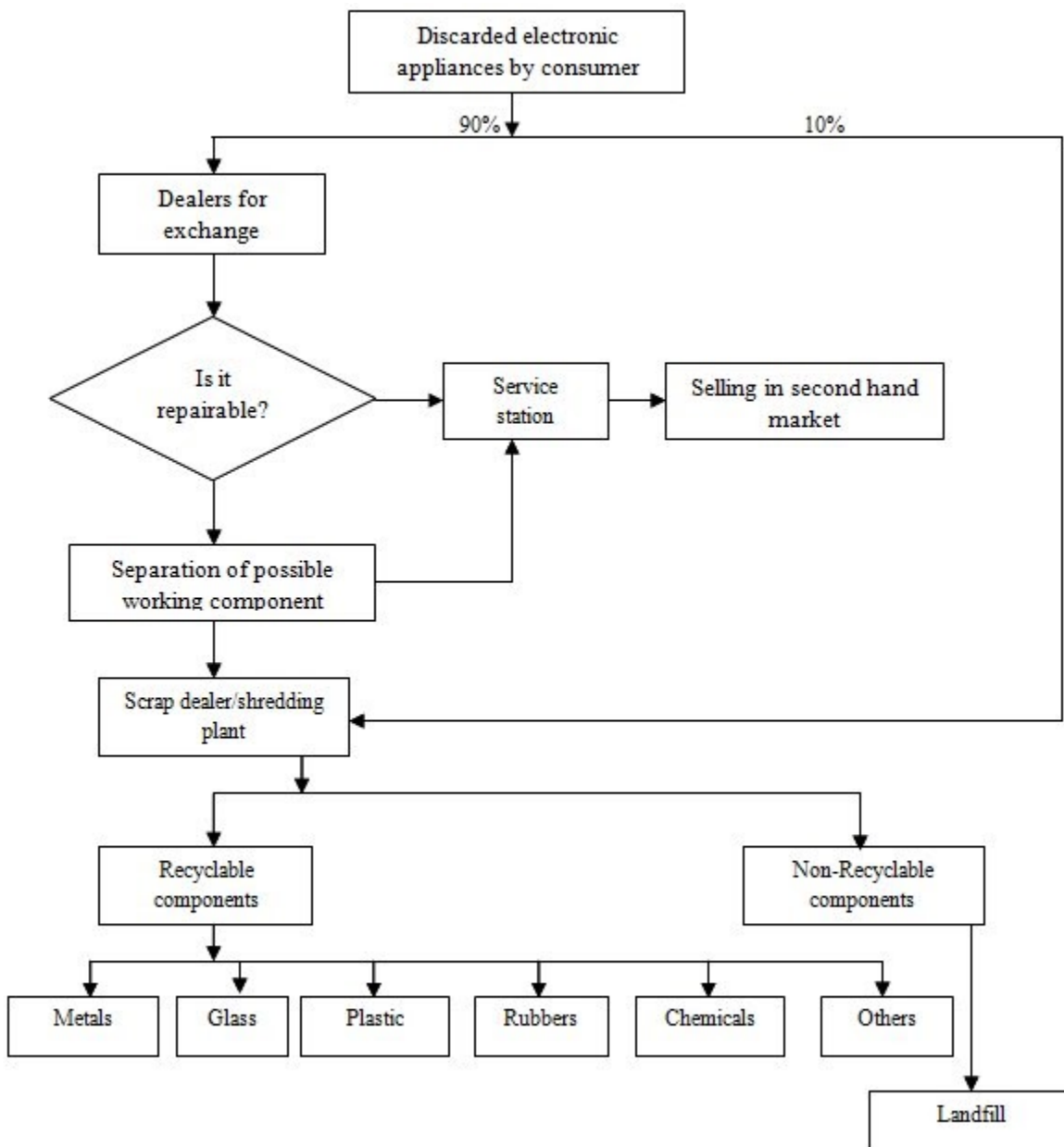


Figure: Flow chart of the present E-waste trade cycle

### 3. Proposed Candidate System

#### 3.1 Potential Candidate System:

Our proposed candidate system is based on effective monitoring and regulatory activities throughout the whole life cycle of e-products. The proposed system is based upon some fundamental characteristics of e-waste recycling system but there are some major changes. The proposed system will be transparent in the e-waste collection as well as will be channelize for preventing stakeholders who follow unjust ways to justify their collection targets. It will also make the owners accountable for the e-waste they deposit as they claim.

Three potential candidate systems are identified which works towards achieving the same goal. The candidate systems are chosen such that it fulfills the requirements of the users that were extracted from the information gathering methodology (survey, interviews etc). The features of the candidate systems are stated in a tabular form as following:

Table: Features of the candidate systems

Candidate Systems	Features
E-waste management using digital ledger and cryptographic transaction (C1)	<ul style="list-style-type: none"><li>• The system will be built upon blockchain where primary nodes are manufacturers, suppliers, retailers, customers and recyclers.</li><li>• The product details will be added by the manufacturers.</li><li>• The transfer in ownership from the manufacturers to the suppliers will be logged.</li><li>• The information of distributing the products from the suppliers to the retailers will be stored.</li></ul>

	<ul style="list-style-type: none"> <li>• sales from the retailers to the customers will be inserted into the blockchain network.</li> <li>• E-waste will be disposed in to the e-waste center by the customers in exchange of digital token.</li> <li>• smart contracts will be deployed in the e-waste module where digital token will be given as incentive to the customers who properly dispose their e-waste properly in the waste collection center.</li> </ul>
E-waste management using ERP (Enterprise resource planning) (C2)	<ul style="list-style-type: none"> <li>• Pickup requests can be made by the normal users, scrap dealers, local e-waste collectors and corporate users.</li> <li>• E-waste will be collected by the e-waste collector.</li> <li>• Refurbish-able products will be updated in the page after refurbishing is done.</li> <li>• Nonrecyclable products will be exported.</li> <li>• All records will be stored manually in a centralized database.</li> </ul>
E-waste collection system using Iot (C3)	<ul style="list-style-type: none"> <li>• The attached RFID tags can be scanned by the users and E-waste can be disposed.</li> <li>• There will be smart e-waste collection boxes in different areas.</li> <li>• Users will be guided to the nearest collection box by mobile app using GPS.</li> <li>• Automated e-mail alert system will be used to notify the E-waste center to collect the e-waste from the boxes which are full (80%).</li> <li>• User Information and qantity of the disposed E-waste will be stored in the cloud database.</li> </ul>

Hardware and software requirements for each candidate system are also identified to visualize the practical system models:

Table: HW and SW requirements of the candidate systems

Candidate Systems	Hardware	Software
E-waste management using digital ledger and cryptographic transaction (C1)	none	Remix (a browser based compiler), Ganache (Creating private Ethereum blockchain ), VS Code (Code editor for developing dApp), Meta-Mask (browser extension)
E-waste management using ERP (Enterprise resource planning) (C2)	none	Oracle , Cloud server.
E-waste collection system using Iot (C3)	photoelectric , radio frequency identification (RFID), weight, infrared and ultrasonic sensors.	Wireless Fidelity (Wi-Fi) module, e cloud servers, mobile/web applications



### 3.2 Characteristics of Candidate System

We proposed three candidate systems in potential candidate systems. In the below table we compared the characteristics of these systems. The first candidate system is based on blockchain and smart contracts. The second candidate system is based on enterprise resource planing of an e-waste management system. The third candidate system is RFID based e-waste management system using IOT.

Table: Characteristics of the proposed candidate system

<b>Characteristics</b>	<b>E-waste management using digital ledger and cryptographic transaction (C1)</b>	<b>E-waste management using ERP (Enterprise resource planning) (C2)</b>	<b>E-waste collection system using IOT (C3)</b>
Decentralized database	Data is stored in the blockchain in a distributed fashion ensuring no centralized database	Data stored in a centralized database of the recycler enterprise	Data is stored in a centralized database of smart receptacle operator
Smart contract usage	Smart contract is used to for automating transactions and product traceability	No smart contract is used	No smart contract is used
Digital token usage	Digital token system is present for increased user incentive	No digital token system	No digital token system
Automated traceability	Automated traceability of product from manufacturer to	Traceability can be ensured manually	No traceability is done

	recycler is ensured using smart contract		
Intermediate authority independency	Blockchain essentially removes the need for an intermediate authority	Intermediate authority is needed for accountability	Intermediate authority is needed for accountability
RFID tag scanning	No RFID tag scanning is done	No RFID tag scanning is done	Integral part of this system
Smart waste receptacle	No smart waste receptacle is used	No smart waste receptacle is used	Integral part of this system

### 3.3 Performance and Cost-Effectiveness of the Candidate Systems:

After stating the characteristics, performance and effectiveness of the proposed candidate systems, It is required to choose the best candidate system among them. For this some key performance indicator was developed to compare these systems. The notable KPIs are Accountability, monitoring, transparency, traceability, Security and all. The E-waste management using digital ledger and cryptographic transaction is good at Traceability and security. E-waste management using ERP is very cost effective and E-waste collection system using Iot is excellent in collection process. Here, each candidate system's performance, cost etc are evaluated using qualitative measures which are given as follow:

Table: Candidate qualitative evaluation matrix:

<b>Evaluation Criteria</b>	<b>E-waste management using digital ledger and cryptographic transaction (C1)</b>	<b>E-waste management using ERP (Enterprise resource planning) (C2)</b>	<b>E-waste collection system using Iot (C3)</b>
Accountability	Excellent	Bad	Bad
Monitoring	Excellent	Very bad	Good
Transparency	Excellent	Very bad	Good
Traceability	Excellent	Good	Bad
Security	Excellent	Good	Good
Rate of waste disposal	Very Good	Bad	Good
Information accuracy	Excellent	Bad	Bad
Coordination	Excellent	Good	Bad
Development cost	Expensive	Less	More expensive
User friendly	Very Good	Good	Good
Collection process	Good	Very good	Excellent
User incentive	Excellent	Good	Bad

As the key performance indicators and cost data might not always produce the best candidate system, A quantitative weighted rating is used to weight the importance of each criterion where we assigned some weight based on their necessity and we calculated the total weight of each candidate system and chose the highest weighted system among them.

Table: Weighted matrix for the Proposed System

<b>Evaluation Criteria</b>	<b>Weighting factor</b>	<b>C1 Rating</b>	<b>C1 Score</b>	<b>C2 Rating</b>	<b>C2 Score</b>	<b>C3 Rating</b>	<b>C3 Score</b>
Accountability	5	5	25	1	5	3	15
Monitoring	4	5	20	1	4	3	12
Transperancy	4	4	16	1	4	3	12
Traceability	5	5	25	4	20	3	15
Security	5	5	25	4	20	4	20
Rate of waste disposal	5	5	25	3	15	4	20
Information accuracy	5	5	25	3	15	3	15
Coordination	3	5	15	4	12	3	9
Development cost	4	2	8	5	20	1	4
User friendly	3	4	12	3	9	3	9
Collection process	3	4	12	4	12	5	15
User incentive	4	5	20	4	16	2	8
Total			228		152		154

### **3.4 Selection of the Best Candidate System**

Among the three candidate systems we select the E-waste management using digital ledger and cryptography transaction as the best one. As it's the combination of better characteristics, better performance and more information accuracy. It also has the highest score in the weighted evaluation matrix which makes it more suitable than the other two candidate systems.

The reasons are also specified below:

1. It is more accountable than other systems.
1. 2.It is better in traceability.
2. 3.It is more secure.
3. 4.It has higher information accuracy.
4. 5.Rate of waste disposal is also higher in this system.
5. 6.It offers better transparency.
6. 7.It's more user friendly.