4. SOFTWARE DEVELOPMENT OF E-WASTE MANAGEMENT SYSTEM FOR SMART CITIES

4.1 Introduction

The rapid growth in the population is supplemented with an increasing demand for more infrastructure and technology facilities. Employment and gaining a balanced economy is another concern for a country having such a rapidly expanding population, ultimately leading to the emergence of new cities and urban areas. A 'smart city' is developed upon numerous distinct elements and e-waste management is one of these vital aspects. For instance, today, to address the rising concern of carbon emissions in construction process contractors are mandatorily asked to utilize equipment's as per Euro-IV standards. Hence, for employing such operational standards we need to have active participation and acceptance from the contractors in utilizing equipment's as per the prescribed technologies. Similarly, the effectiveness of e-waste management system depends upon the active participation of all the stakeholders and citizens. E-waste management is of grave importance to an urbanized region which faces the constant pressure of increasing population density, rising infrastructural and electronic demands and expanding inflow with technology revolutionization.

There is tremendous growth in electronic industry, which has put India at crossroads to facilitate smart way of e-waste disposal as sustainable model.

This chapter explains self-powered sustainable business and software model for the e-waste management for Pune, Maharashtra which is scalable to support entire country.

In Chapter 2 and Chapter 3 critical gap is gathered on life cycle management of the e-waste within Pune and Maharashtra and India overall. There is need of strong centralized system for management of e-waste in-flow and out-flow which would facilitate the corporate and household consumers to easily dispose e-waste in their premises, also assuring overall monitoring and control of e-waste by government.

4.2 Smart City Business Model

New Business Model is proposed for E-waste management of the City, State
and country by creating handshake between the end-user/s and Recycler giving visibility to the government on E-waste generation and its consumption. **The software is created as part of the research to support the model. It is Business to Business (B2B) , Business to Customer (B2C) and Business to Government (B2G) Business Model**

The model has been discussed with P.M.C. Joint Commissioner of Solid Waste and E-waste Management and with the M.P.C.B. Environment Officer on Feb-2016. There was extreme appreciation shared by the P.M.C. Joint Commissioner for the work done. The copy of the software and copy of synopsis of the research has been shared with the PMC Commissioner for the practical use and have been requested to share the feedbacks.

![Smart City Business Model](image)

**Fig 4.1 Smart City Business Model**

I. User Registration into the Software system per their profile as - Recycler , End User-IT Companies, and Government .

ii. The IT Companies and Individual users can enter the E-waste items to be sold with their preferred price also status as - Working or Non-Working.

iii. The other IT Companies can buy the pre-owned Working items at lower cost. They
can bid for same. It enhances re-usability and end of life of the equipment.

iv. The End-user holds rights to sell the equipment to his preferred quote and customer.

v. The Non-working equipment available in the system can be bought by the registered recycler’s. The prices are negotiated with the seller.

vi. Government will be able to see the transactions at real time. It'll be able to calculate the E-waste generated from City/State and its end state.

Benefits of the Model

a. Yearly disposal from the IT Company can be tracked through the system.

b. It provides “Open Market” concept where supplier and customers are available in one place, allow fast circulation of items.

c. E-waste can be resold through the system, which allows extending the EOL of the equipment.

d. Recycler’s can reach the IT Companies to buy the E-waste system.

e. It provides ONE STOP shop for E-waste disposal.

Business to Business Model

Online Auction System to Sell Computers, laptops and printers which have reached EOL and are still in working condition. It provides small and big business consumers looking for second hand low cost devices to purchase the machines online close to their locality. Recyclers can purchase the "Non Working" equipments online.

Business to customer Model

The corporate houses can sell the Working equipment reaching EOL at low cost, for household use or to students as individual customers.

Business to Government Model

Government has ability regulate the outflow of E-waste and channels adopted for reuse and recycling.
4.3 Scope of Implementation

The Application is hosted on the registered site and is accessible universally for use. www.ewastepune.co.in

4.4 Technical Specification

Application is build using ASP.NET, EDMX and LinQ.

ASP.NET - ASP.NET is a development framework for building web pages and web sites with HTML, CSS, JavaScript and server scripting.

EDMX - An .edmx file is an XML file that defines a conceptual model, a storage model, and the mapping between these models. An .edmx file also contains information that is used by the ADO.NET Entity Data Model Designer (Entity Designer) to render a model graphically.

LINQ - LINQ to SQL provides a runtime infrastructure for managing relational data as objects without losing the ability to query. Your application is free to manipulate the objects while LINQ to SQL stays in the background tracking your changes automatically.

Database: SQLServer 2008 R2 Server.

4.5 Functional Model of E-waste Management System

The Software Design and Functionality is divided into 4 sections based on the Users:

1. Registration screen for the user types - consumer, recycler, government
2. Customer functionality-Buying or selling the e-waste
3. Recycler’s functionality to buy e-waste.
4. Government reporting and control - to monitor the transactions and successful and unsuccessful deals.

4.5.1 Registration Process

The login screen provides link for registration for the consumers (corporate, domestic household) who are taking out e-waste, recyclers (registered e-waste recyclers)
and Government bodies who will have access to monitor the transactions and disposal route of the e-waste.

The Fig 4.2 gives the User Login screen which is accessed on reaching - www.ewastepune.co.in the registration screen Fig 4.3, has 15 user fields to enter “New User” details for the registration.

i. Username is unique field, hence it will throw an error if the new user tries to register with existing user.

ii. “Password” to enter access restriction to the user login, and is personal to the userid.

iii. “Confirm Password” are to validate the password entered by the user. It should be same as the password entered in ii.

iv. “Contact Number” takes the phone number of the person or organizations registration

v. “Email Id” contact email address of the user.

vi. “Size of Organization” the number of employees in the organization

vii. “Type” type of role of the user - IT or Recycler or Government.

viii. “Contact Person Number” Contact number of the user

ix. “Contact Person Name” Name for identification of the user.

x. “Name of Organization”

xi. “Address” Address of the user

t. “State” State in which the user belongs. the application will display drop down list from which the user can select the state.

xiii. “City” City where user is situated, It is drop down list refreshed, based on state selected.

xvi. “Pin-code” User will enter the Pin-code of his/her state.

xv. “Registration Number” Registration number of the organization or the PAN number of individual user.
Fig 4.2: Login Screen www.ewastepune.co.in
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Fig4.3 : User Registration Screen

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4.5.2 Login-Authorization

The registered Users are authenticated based on Login-Password credentials and the "Type". Fig 4.4 shows Login Authentication.

Login screen has three user boxes - UserName, Password and Type.

a. "Type" Field in Fig 4.4 specifies user type among the three broad category of - IT, Government and recycler.

b. “User Name” Login name of the registered user.

c. “Password“ User password to be entered by the registered user.

User is authenticated on his credentials, and allowed access. If any of the fields is inaccurate, the access is denied to the system.

As soon the user logs into the system, he sees his username and Role (Type) displayed on top left of the screen (Fig. 4.5).

4.5.3 Customer Functionality

The Tool Bar on the top in (Fig. 4.5) Grey lists Actions which User can Take below actions.

- Sell the Products
- Buy the Products
- Requested By Me
- Logout
Fig 4.4 : Login Screen with Type details
Fig 4.5: Customer Home Page
4.5.3.1 Sell Module for Customer (Auction)

As the user (Type or Role as IT) logs in, he sees the screen Fig 4.5 which lists the products he has registered to be sold. The Tool Bar on the top in Grey lists Actions which User can Take. The screen displays the following information regarding the products registered to be sold:

i. Product Name

ii. Product Type

iii. Start date (Date of buying)

iv. Expiry date / End Of life date

v. Quantity

vi. Working Status (Working/Non-working)

vii. Status (transaction status-Requested, sold, delivered, closed; it is drop down field)

viii. Original price (Amount product was purchased)

There is an Edit link at the end of the row (Fig 4.5 and Fig 4.6), allowing the seller to change the parameters.

Fig 4.6 shows the expansion of the New product entry screen for selling.

Fig 4.7 lists the products (e-waste) added to be sold by the user.
Fig 4.6: Sell Screen for addition of products
Fig 4.7: List of the products User has put for Sale

<table>
<thead>
<tr>
<th>Product</th>
<th>Product Type</th>
<th>Start Date</th>
<th>Expiry Date</th>
<th>Quantity</th>
<th>Working Status</th>
<th>Status</th>
<th>Original Price</th>
<th>Sale Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hitachi laptop</td>
<td>Computer</td>
<td>05/10/2014</td>
<td>01/09/2015</td>
<td>1</td>
<td>Working</td>
<td>Open</td>
<td>10000.00</td>
<td>4000.00</td>
</tr>
<tr>
<td>Pen</td>
<td>Computer</td>
<td>10/02/2016</td>
<td>02/02/2016</td>
<td>12</td>
<td>Working</td>
<td>Open</td>
<td>120.00</td>
<td>110.00</td>
</tr>
<tr>
<td>Asv</td>
<td>Computer</td>
<td>01/02/2016</td>
<td>17/02/2016</td>
<td>10</td>
<td>Working</td>
<td>Open</td>
<td>123.00</td>
<td>123.00</td>
</tr>
</tbody>
</table>
4.5.3.2 Buy Module for Customer (Auction)

User can buy products put-up for sale by other Users. It is auction setup, where the expected price is set by the Supplier and Buyer can quote his/her price. Supplier has final choice to accept the bid and close the transaction with any of the buyer. This functionality allows products re-use within the main stream.

Fig 4.8: Buyer Screen
Fig 4.7 shows the Buy screen, this screen opens when “Buy” option from grey bar is clicked. It shows all the products registered for sale by other users, there is also “Buy” link at the end of the row. On clicking the link the “Buy” screen opens, which allows the user to enter his bid for the product.

4.5.3.3 Consumer “Request To Me” Module

The module provides information on the bids submitted by other buyers for the products put up by the user for sale (see Fig 4.9).

The user can select the quote/bid and contact the Requester and close the deal. He changes the status of the transaction as “Sold”. Once the inventory is delivered status will be changed to “Delivered” and on completion of the payment and receipt of the inventory status has to be changed to “Closed”; to complete the transaction (see Fig 4.10).

4.5.4 Recycler Functionality

These set of functions defined specifically for Registered Recyclers. They are enabled to continuously evaluate generated e-waste for recycling, and maintain their operations.
Fig 4.9: Consumer - "Requested To Me” Module
Fig 4.10: Change status of the Transaction on acceptance of Request
4.5.4.1 Recycler Registration Screen

The recycler will register as “Type” - Recycler and then login as the User with “Type “ recycler, with relevant details. There are mandatory fields which are marked as asterix and are prompted to be filled fig. 4.11. There will be error message prompted, if the fields are left vacant or not filled appropriately as per direction. Details of fields are explained in Sec 4.5.2.

4.5.4.2 Recycler Login

After Registration to the system is completed, the Recycler can login to the system Fig 4.13. The Username and Password is authenticated against the credentials provided during the Registration.

4.5.4.3 Recycler Home Page

On logging to the E-Waste Management System as Recycler, the user can see the screen as in Fig 4.12. All the products listed to be sold are visible to him. He/She can send request for purchase, with his own price quote against the one provided by the user selling the products. "Buy" Link at the end of Row provides the facility to do it.
Fig 4.11: Registration Screen for Recycler

<table>
<thead>
<tr>
<th>User Name</th>
<th>recycler5</th>
<th>Contact Number</th>
<th>7755326528</th>
</tr>
</thead>
<tbody>
<tr>
<td>Password</td>
<td></td>
<td>Email</td>
<td><a href="mailto:recycle5@hotmail.com">recycle5@hotmail.com</a></td>
</tr>
<tr>
<td>Confirm Password</td>
<td></td>
<td>Size Of Organization</td>
<td>100</td>
</tr>
<tr>
<td>Type</td>
<td>Recycler</td>
<td>Contact Person Name</td>
<td>Mr. Soni</td>
</tr>
<tr>
<td>Name Of Organization</td>
<td>Ecoreco</td>
<td>Contact Person Number</td>
<td>7755326528</td>
</tr>
<tr>
<td>Address</td>
<td>Khar, Mumbai</td>
<td>Registration Number</td>
<td>MH 10053</td>
</tr>
<tr>
<td>State</td>
<td>Maharashtra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>Mumbai</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PinCode</td>
<td>400052</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig 4.12: Login as Recycler
Fig 4.13: Recycler Home Page
4.5.4.4 Recycler “Request by Me” Module

User can see the status of the Requests he has send to the E-waste Product suppliers. He can follow through direct contact via email or phone. He can check the status of the Product whether it was sold to another recycler or IT Organization.

4.5.5 Government Controller Setup

The Functionality enables Government to monitor the movement of E-waste within the cities. The e-waste being re-sold or re-use can be tracked. Also the e-waste which is reaching the recyclers can be tracked. Incase the e-waste is not being taken by recyclers; it can be easily questioned by the government.

The system gives immense authority to Government to monitor and control. It opens opportunities for employment and new startups in collection and transportation, and new recyclers. It will open opportunities for e-government and e-universities on costeffective e-waste cloud. This gives immense opportunities for the Government to enhance and amend the E-waste Laws. Additionally provides huge playground for NGO's to create enhanced "Go Green” and cleanliness initiatives.

4.5.5.1 Login Screen

In Fig 4.15, Government user enters its credential with the profile selected as "Government" from the drop down menu.
Fig 4.14: Recycler - Request By Me
Fig 4.15: Login Screen
4.2.5.2 Government Home Page

During the first login there will be prompts for saving the password in the Cache Memory (Fig 4.16, ), this will facilitate easy login to the web page next time, without prompting for password.

There are four fields (Fig 4.17) for selection in order to generate desired report.
- Date – Start Date and End date selection
- State – Gather details as per Indian state selection
- Status – Transaction status - Open, Requested, Sold, Delivered, Closed.

4.5.5.2 Government Report

Government Bodies like Maharashtra Pollution Control Board (MPCB), State Government - Environment Ministry and Central Pollution Control Board (CPCB) have ability to view the movement of E-waste generated in the city or state. They can view the quantity being re-used and being send for the recycling (Fig 4.18, 4.19). The Search Options are classified as:

1. Based on Period where transactions were done - Start Date and End date
2. Based on State
3. Based On the Transaction Status
Fig 4.16: Government Home Page
Fig 4.17: Government Reports
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#### E-Waste Management System

![E-Waste Management System](image)

**Welcome Maharashtra (Government)**

- Change Password
- Logout

**Date**

<table>
<thead>
<tr>
<th>Date</th>
<th>Status</th>
<th>Quantity</th>
<th>Original Price</th>
<th>Sale Price</th>
<th>Buyer Name</th>
<th>State Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>04-05-2015</td>
<td>Open</td>
<td>1</td>
<td>7000.00</td>
<td>2000.00</td>
<td>Zeenat2</td>
<td>Maharashtra</td>
</tr>
<tr>
<td>14-04-2016</td>
<td>Open</td>
<td>1</td>
<td>10000.00</td>
<td>4000.00</td>
<td>Zeenat</td>
<td>Maharashtra</td>
</tr>
<tr>
<td>01-02-2016</td>
<td>Open</td>
<td>12</td>
<td>120.00</td>
<td>123.00</td>
<td>Zeenat</td>
<td>Maharashtra</td>
</tr>
<tr>
<td>01-02-2016</td>
<td>Open</td>
<td>12</td>
<td>123.00</td>
<td>20000.00</td>
<td>Zeenat</td>
<td>Maharashtra</td>
</tr>
</tbody>
</table>

### Fig 4.18: Reports

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Fig 4.19: E-waste Transactions