

**NANYANG
TECHNOLOGICAL
UNIVERSITY**
SINGAPORE

Final Product Report

for
OneStop E-Cycle

Version 2.1 approved

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CZ2006 – SS2 – Group 3

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Revision History

Name	Date	Reason For Changes	Version
Initial draft	6/2/22	Initial draft	1.0

Sprint 1	22/2/22	Changes to functional description and requirements accordingly to current production	1.1
Sprint 2	23/3/22	Finalize all contents based on the final products	2.0
Final revision	15/4/22	Finalize all contents, clean up formatting	2.1

1. Introduction

1.1 Purpose

This document is written specifically for the application *OneStop E-Cycle*, version 1.41, made by group JamesBond-1 for the course Cx2006 - Software Engineering. This document will cover information about the products, including functional and non-functional requirements, key features, technical design, software validation and possible future roadmap.

Website is deployed at: <https://onestop-e-cycle.vercel.app/>

Demonstration of the demo: <https://www.youtube.com/watch?v=pd4CT1X8o3c>

1.2 Product Scope

OneStop E-Cycle is a standalone product. It is designed to be a one-stop portal for electronic waste recycling in Singapore. It aims to increase the e-waste recycling rate in Singapore by providing an easy way to find recycling points, providing information about e-waste, and promoting community events to raise public awareness.

1.3 Intended audience and Reading Suggestion

1.3.1 Intended audience

- Developers
- Product managers
- Users
- Marketing staff
- Testers

1.3.2 Reading Suggestion

The rest of the document is organized as follows: [Section 2] gives an introduction of our product. Interface requirement is introduced in [section 3], followed by detailed functional requirements and analysis diagrams in [section 4]. Non-functional requirements and other requirements are discussed in [section 5]. The design process and models are documented in [section 6], followed by testing in [section 7]. Finally, future work is covered in [section 8].

1.4 Target user

Our product targets people who use electrical and electronic devices in Singapore. According to 2019's statistics, over 98% of Singaporeans use digital devices, so we wish to target this portion of the Singapore population.

2. Overall Description

2.1 Product Functions

The application includes these four key features:

- Allows users to search the database for a list of e-waste recycling points, filtered by the distance from the chosen location and/or the types of e-waste, then display the points on a map.
- Shows information related to e-waste recycling, including types of e-waste, how to process each type, and some statistics. This information aims to raise awareness of e-waste recycling.
- Shows a list of e-waste recycling events happening in Singapore.
- Allows users to subscribe to a newsletter using their email addresses. The newsletter contains more information about e-waste and upcoming events, and it will be maintained by a separate group of authors not related to the main product.

2.2 User Classes and Characteristics

The application is tailored for people who regularly use electrical and electronic products. We classify them into two groups of people based on their awareness of e-waste recycling:

- **Regular users:** people who change electronic items regularly and throw away their items. These users will benefit from the recycling points searching and informative features. In order to reach more people, the website needs to be optimized to be shown on search engines and media pages. More about the Search Engine Optimization indicator will be discussed further on.
- **Environmentalists:** people who are aware of e-waste recycling and frequently participate in recycling activities. These users will benefit from the recycling points searching and Event Hub features.

2.3 Operating Environment

Our web application works on all ES6 (2015) compatible browsers without other dependencies. However, some functionalities will only be available for supported browsers:

- Get current location requires browser Geolocation API.

2.4 User Documentation

All the code base will be fully documented with javascripts docs. README.md will provide short instructions on how to run and develop on localhost. Details about deployment and core-packages dependencies will also be noted in this file.

2.5 Dependencies

Our product make critical use of these npm packages:

- @react-google-maps/api v2.7.0
- @emotion/react v11.7.1
- @emotion/styled v11.6.0
- @mui/material v5.4.0
- @mui/icons-material v5.3.1
- sweetalert2 v11.4.8
- firebase v9.6.10
- next v.12.1.0
- react v17.0.2
- fs v0.0.1-security
- remark-html v15.0.1
- remark v14.0.2

3. External Interface Requirements

3.1 User Interfaces

The user interface follows a responsive design that ensures that the web pages can be rendered properly on all devices and screen sizes. Clickable links are indicated using buttons or underlined texts. Sans-serif fonts are used to give a modernized interface. Green is used as the primary color on the page as a reference to the environment.

3.2 Hardware Interfaces

Any modern computer and smartphone with access to the Internet should be able to access the application. Actual hardware requirements depend on the operating system and the application used by the device to access the Internet. GPS functionalities are optional to use the location feature given on the Recycling page.

3.3 Software Interfaces

All modern browsers with access to the web page can run the application. We recommend these browsers below for the best experience:

- Chrome version 58 or later
- Microsoft Edge version 14 or later

- Firefox version 54 or later
- Safari version 10 or later
- Opera version 55 or later
- Other chromium-based browsers

3.4 Communication Interfaces

Any web browser with support for HTTPs protocol is sufficient to use the product. An active email address is optional to sign up for and receive the newsletter.

The website shall adopt Single Page Application (SPA) behavior

- System interacts with users by dynamically rewriting the current web page with new data instead of the browser's default reloading methods.
- All necessary HTML, CSS, JS scripts are retrieved dynamically by being added/loaded to the page upon user interactions, page refresh never occurs
- System must enable faster transitions that make the website feel like a native app.

4. Functional Requirements

4.1 Main functional requirements

4.1.1 Main objectives

- Allow users to search and navigate to nearby E-waste recycling points
- Display general information and tips regarding recycling E-waste materials
- Include descriptions and allow users to subscribe to E-waste recycling events happening in Singapore.

4.1.2 Components

1) Home Page

1.1 The system must give a general introduction to application functions and E-waste recycling.

2) Information Page

- 2.1 The website must show the definition of E-waste.
- 2.2 The website must show the characteristics of E-waste.
- 2.3 The website must show the benefits of recycling E-waste.
- 2.4 The website must show 8 types of E-waste:
 - 1) ICT equipment
 - 2) Large household Appliance
 - 3) Electric Mobility Device
 - 4) Household Battery
 - 5) Lithium-Ion Portable Battery

- 6) Consumer Electric Vehicle Battery
- 7) Consumer Lamp (Bulb)
- 8) Consumer Lamp (Fluorescent Tube)

2.4.1 The website must show the description of each E-waste type.

2.4.2 The website must show examples of each E-waste type.

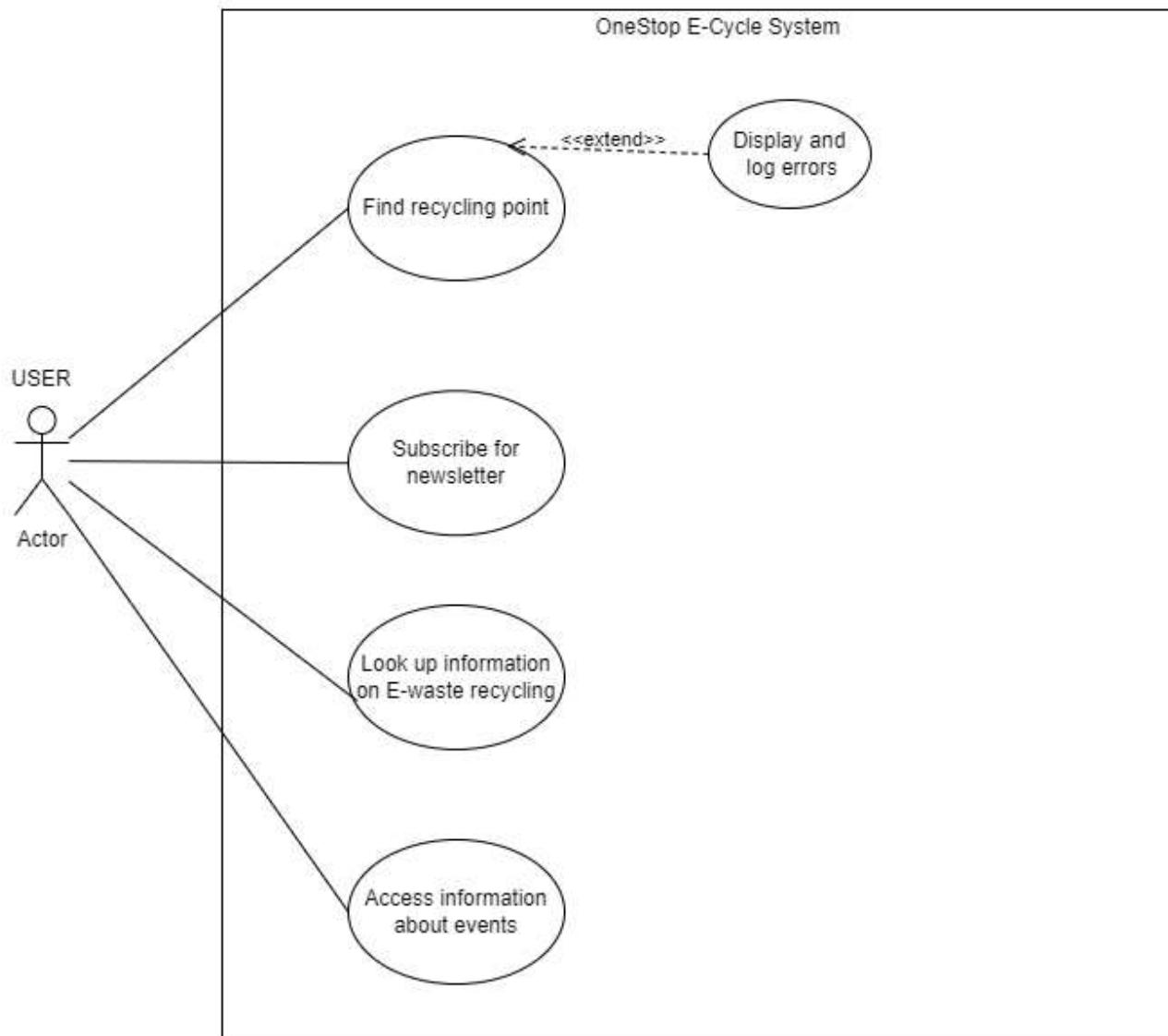
3) Recycling Page

- 3.1 The website shall allow users to enter a location.
- 3.2 The user shall use their current position as the input location.
 - 3.2.1 The website must request access to the user's current position.
 - 3.2.1.1 If the user grants permission, the system must use the user's current position as the input location.
- 3.3 The webpage shall allow the user to select the displaying range in the list of 500m, 1km, 2km, 3km, 5km, 7km, 10km, or indicate any range.
- 3.4 The website must have the default displaying range of 3km.
- 3.5 The webpage shall allow the user to select the user's type of E-waste.
- 3.6 Upon receiving location input from the user, the website must show a map of all E-waste recycling points within the displaying range.
 - 3.6.1 The displayed E-waste recycling points must accept the user's type of E-waste.
 - 3.6.2 The user shall be able to zoom in and drag the displayed map manually to look at the recycling points around Singapore.
 - 3.6.3 The user shall click on a recycling point.
 - 3.6.3.1 The information about the recycling point must show up.

4) Event Page

- 4.1 The website must display available events about E-waste in Singapore.
 - 4.1.1 The event must include the event's name and date.
 - 4.1.1.1 The system shall redirect the user to the event organizer's page.
- 4.2 The website shall allow the user to subscribe to newsletters/events by entering the user's email.

4.2 Use case diagram



4.3 Use case description

Use Case ID:	UC-01		
Use Case Name:	Find recycling points		
Created By:	Ho Phi Dung	Last Updated By:	Ho Phi Dung

Date Created:	5 Feb 2022	Date Last Updated:	8 Feb 2022
---------------	------------	--------------------	------------

Actor	User
Description	User views available recycling points on the webpage, points are rendered by custom filters.
Preconditions	NIL
Postconditions	Successful completion: recycling points are displayed on the webpage. Failure condition: NIL.
Priority	High
Frequency of Use	Frequently
Flow of Events	<ol style="list-style-type: none"> 1. User access to the “Recycle” page. 2. Website will have a default location=“NTU” and default filters=“all e-waste types, within: 3km”. 3. User optionally searches for a new location or gets a location as the user's current location. 4. User optionally selects additional filters such as range, type of waste, etc. 5. User presses view 6. The recycling page renders the google map instance with a green marker. 7. User optionally clicks on the markers to get more information about the locations.
Alternative Flows	NIL
Exceptions	NIL
Includes	NIL
Special Requirements	NIL
Assumptions	Internet connection is enabled in the device. Google API is configured and running.
Notes and Issues	Need to check for google API key in case it expires.

Use Case ID:	UC-02		
Use Case Name:	Subscribe to OneStop E-cycle mailbox		
Created By:	Duong Ngoc Yen	Last Updated By:	Duong Ngoc Yen
Date Created:	5 Feb 2022	Date Last Updated:	8 Feb 2022

Actor	User
Description	Subscribe to receive e-newsletters, updating information about e-waste events.
Preconditions	NIL
Postconditions	Successful completion: The user subscribes successfully Failure condition: NIL
Priority	Low
Frequency of Use	Rarely
Flow of Events	<ol style="list-style-type: none"> 1. The user goes to the “Event” page. 2. The user enters his email into the subscribe box. 3. The user presses the subscribe button. 4. If the subscribing email is valid and not duplicated, the system adds the user’s email to the mailing list.
Alternative Flows	<p>AF-S4: If the subscribing email is invalid</p> <ol style="list-style-type: none"> 1. The system displays an error message to notify the invalid email. <p>AF-S4: If the subscribing email is valid and duplicated</p> <ol style="list-style-type: none"> 1. The system displays a notification about duplicated email.
Exceptions	NIL
Includes	NIL
Special Requirements	NIL
Assumptions	Internet connection is enabled in the device

	Server backend can process requests during the event The user has an active email account.
Notes and Issues	NIL

Use Case ID:	UC-03		
Use Case Name:	Look up information on E-waste recycling		
Created By:	Vu Duc Thanh	Last Updated By:	Vu Duc Thanh
Date Created:	5 Feb 2022	Date Last Updated:	8 Feb 2022

Actor	User
Description	Display E-waste general information and description of different E-waste types.
Preconditions	NIL
Postconditions	Success Completion: The content is displayed completely on the client's side. Failure Condition: An internal log is written for debugging.
Priority	Normal
Frequency of Use	Rarely
Flow of Events	<ol style="list-style-type: none"> The user clicks on the "E-waste info" tab on the header. The system directs the user to the information page. The user scrolls and reads E-waste information on the page. The user clicks on an e-waste type card. The system displays a popup to show information about that E-waste type. The user closes the popup
Alternative Flows	<p>AF-S5: If the user clicks on "Learn more" button</p> <ol style="list-style-type: none"> The system opens the source page with information of the E-waste type. The user closes the popup
Exceptions	NIL

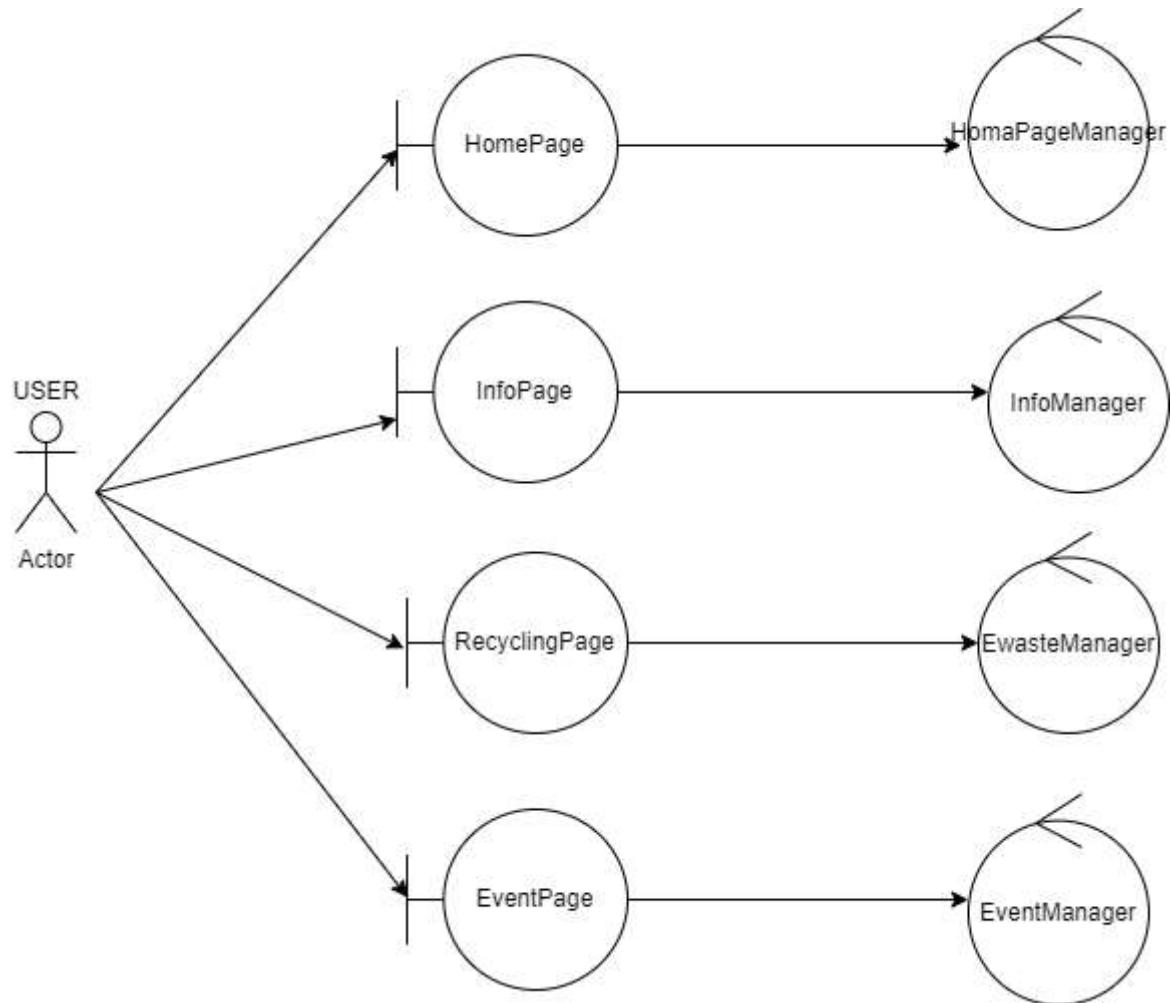
Includes	NIL
Special Requirements	NIL
Assumptions	User has a stable connection to the Internet.
Notes and Issues	NIL

Use Case ID:	UC-04		
Use Case Name:	Access information about an event		
Created By:	Vu Duc Anh	Last Updated By:	Vu Duc Anh
Date Created:	5 Feb 2022	Date Last Updated:	12 April 2022

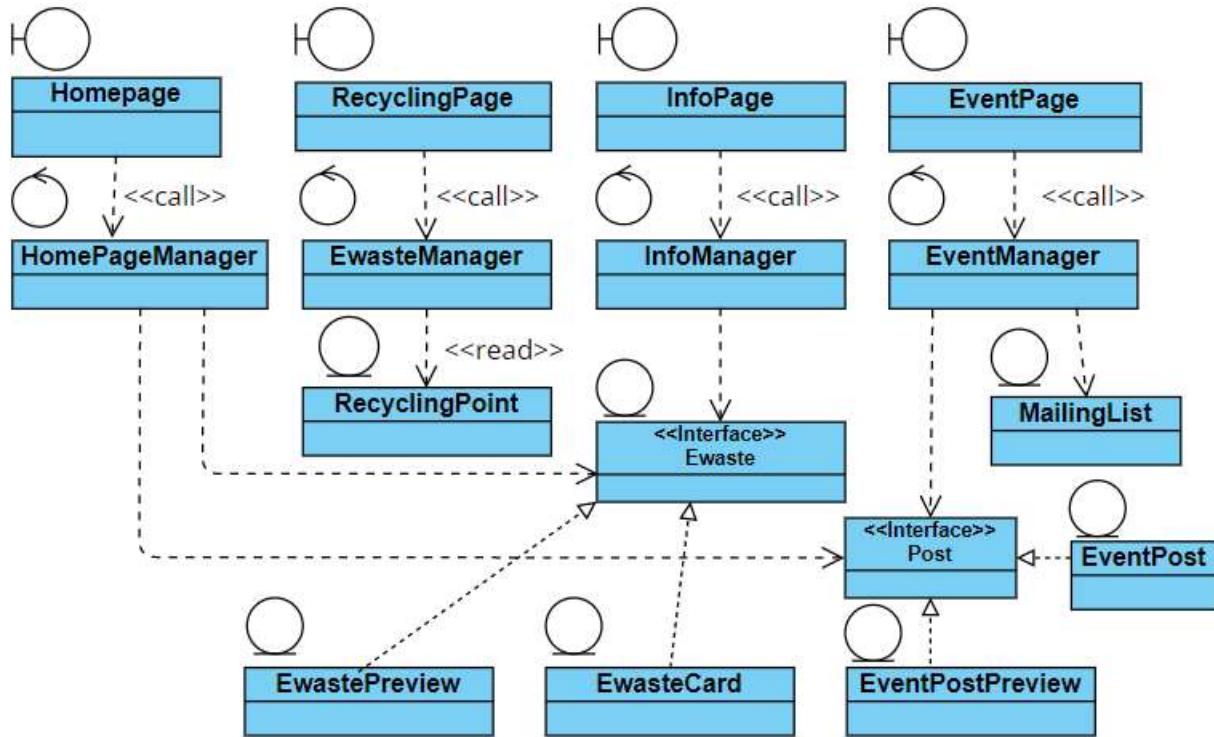
Actor	User
Description	Display information about recycling events in Singapore
Preconditions	The user must be in the Event page. There is a hyperlink of the event.
Postconditions	Successful completion: The user could access information about events in Singapore. Failure Condition: NIL.
Priority	Normal
Frequency of Use	NIL
Flow of Events	<ol style="list-style-type: none"> 1. The user checks through the event names on the Event page. 2. The user clicks on the event tile, which contains a hyperlink to the event post page. 3. The system will route the user to a new tab that contains event information. 4. The user reads through the information on the event post page.

	5. The user clicks on the “Register” button on the event post page. 6. The system opens the official page of the event in a new tab.
Alternative Flows	NIL
Exceptions	NIL
Includes	NIL
Special Requirements	NIL
Assumptions	User has a stable connection to the Internet.
Notes and Issues	NIL

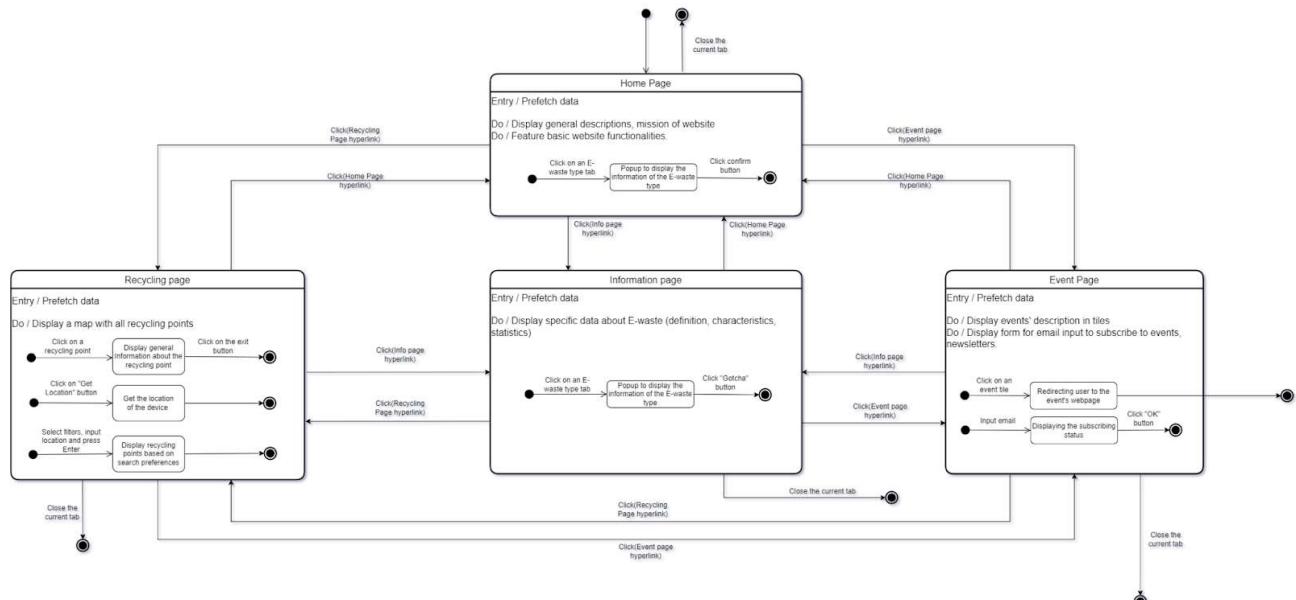
4.4 Key Boundary and Control classes



4.5 Class Diagram



4.6 Dialog map



4.7 Data dictionary

Terminology

Terms	Definition
Recycling point	Location where users can recycle their e-waste. Data of recycling locations are taken from the data.gov.sg website.
E-waste	Electronic products that are unwanted, not working, and nearing or at the end of their “useful life.” Computers, televisions, VCRs, stereos, copiers, and fax machines are everyday electronic products.
Type of e-waste	Different categories of e-waste, including ICT equipment, large household appliances, electric mobility device, household battery, lithium-ion portable battery, consumer electric vehicle battery, consumer lamp (bulb), consumer lamp (Fluorescent Tube)
Event	Event which is related to e-waste and e-waste recycling that are worth taking note of, hosted by external organizations or webpage users' community.
Newsletter	Automatic email regarding relevant information about e-waste. These emails are sent to a network of customers, prospects and subscribers.
Mailing lists	List of emails from users who subscribe to the newsletters.

Event Table

Field name	Data type	Field Length	Constraint	Description
Event title	VARCHAR	100	PRIMARY KEY	Name of an e-recycling event
Excerpt	VARCHAR	100		Description of an e-recycling event
Cover Image	VARCHAR	100		Path to the image of the event
Date	DATE	20		Date of the event
RegURL	VARCHAR	100	NOT NULL	Hyperlink of the event

Recycling point table

Field name	Data type	Field Length	Constraint	Description

RecordNo	INTEGER	100	PRIMARY KEY	Unique ID of recycling location
Recycling point name	VARCHAR	100	NOT NULL	Name of recycling location.
Address	VARCHAR	100	NOT NULL	Address of recycling point
Postal code	INTEGER	8		Postal code of recycling point
Latitude	FLOAT	10	NOT NULL	Geographic coordinate specifies the north-south position of a recycling point on the Earth's surface.
Longitude	FLOAT	10	NOT NULL	Geographic coordinate that specifies the east-west position of a recycling point on the Earth's surface
Type	VARCHAR	100		Represent type of E-waste

Mailing list table

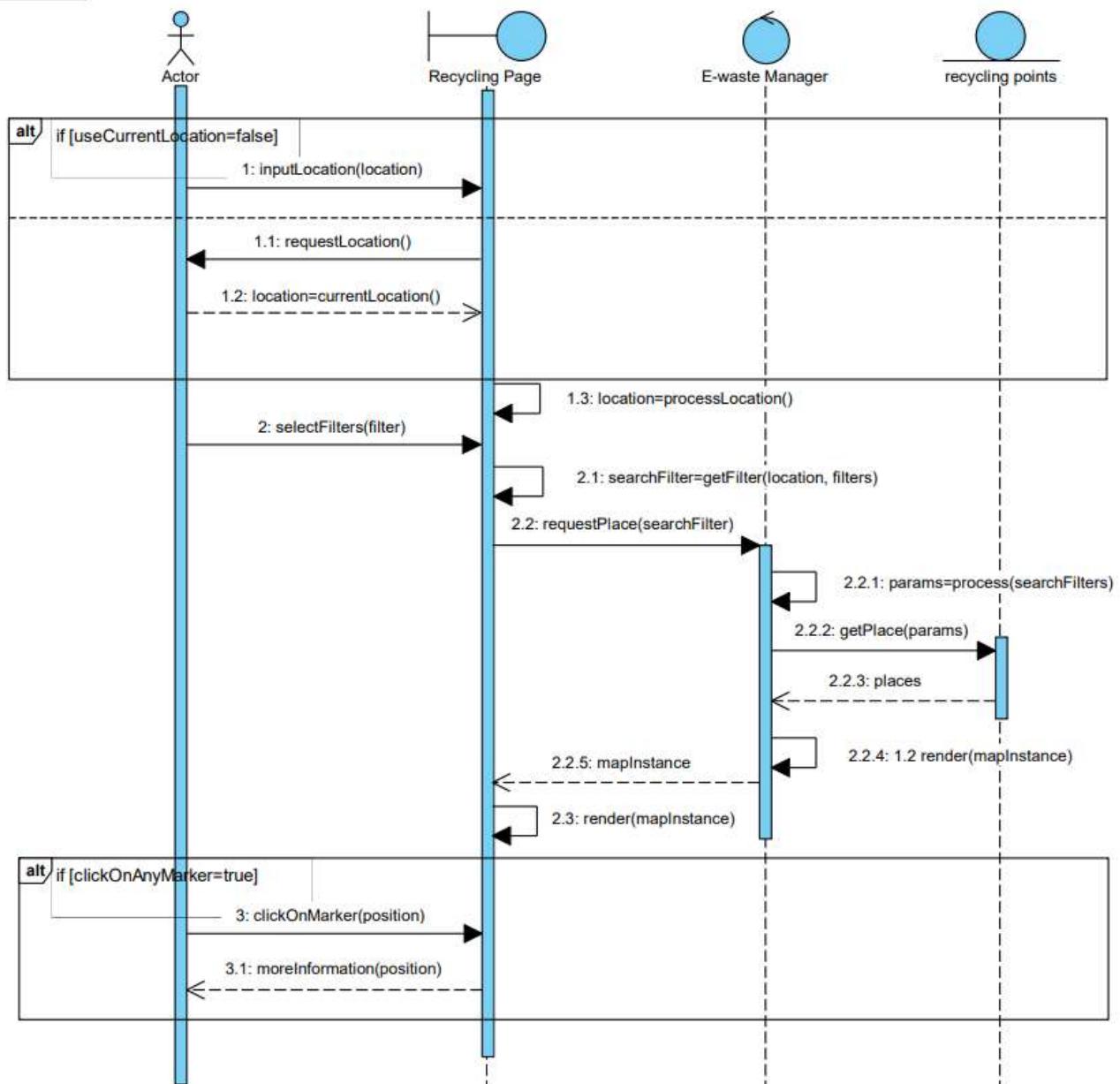
Field name	Data type	Field Length	Constraint	Description
Email	VARCHAR	100	PRIMARY KEY	email of subscribed users
subscriptionDate	DATE	20		date of subscription

E-waste Type Table

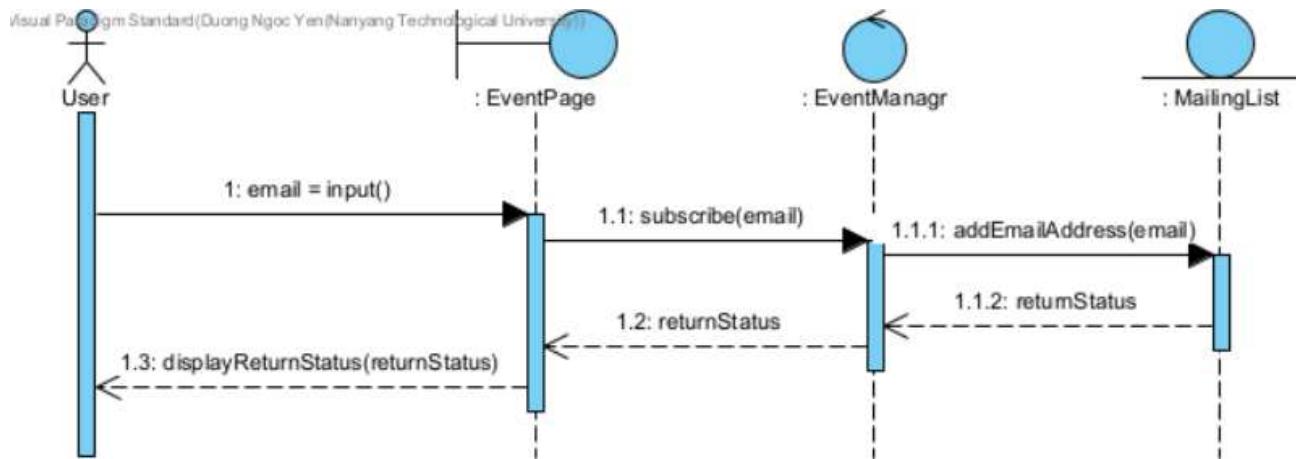
Field name	Data type	Field Length	Constraint	Description
Type	VARCHAR	30	PRIMARY KEY	Type of E-waste
Link	VARCHAR	100		Link to the definition of E-waste
Description	VARCHAR	200		Description of the E-waste types

4.8 Use case implementation

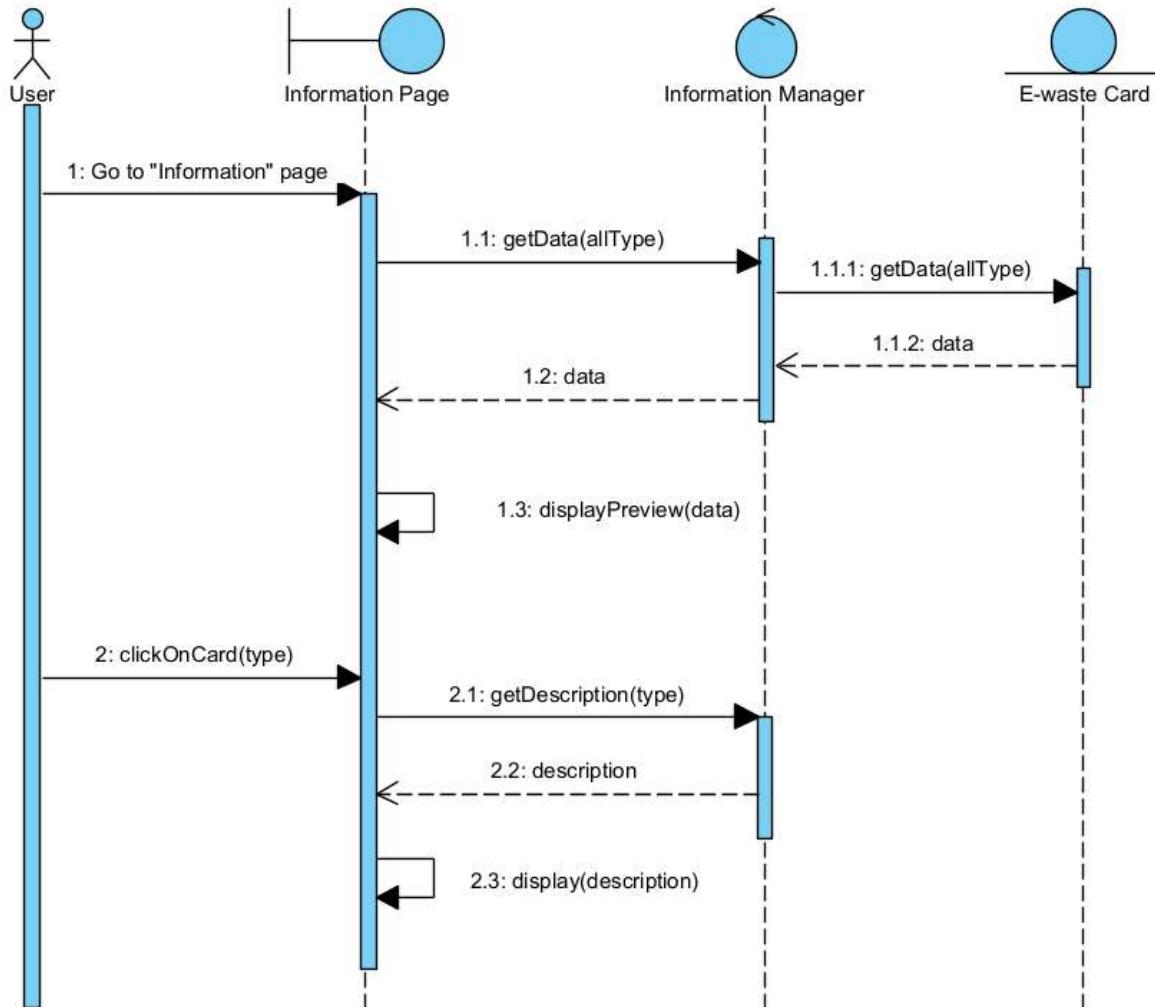
4.8.1 Use Case 01: Find recycling points



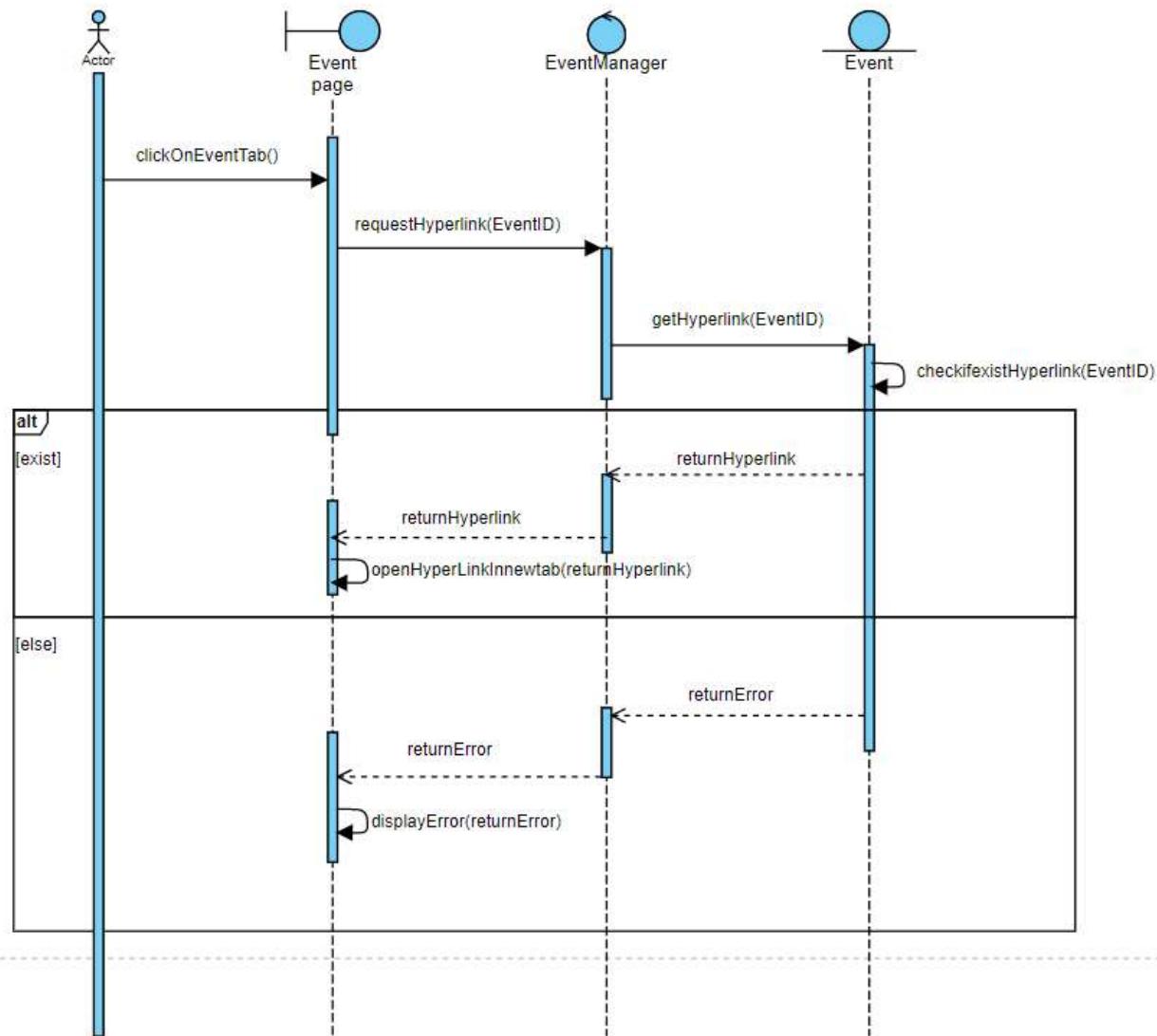
4.8.2 Use Case 02: Subscribe to OneStop E-cycle mailbox



4.8.3 Use case 03: Look up information on E-waste recycling



4.8.4 Use case 04: Access information about an event



5. Nonfunctional Requirements

5.1 Performance Requirements

5.1.1 The system shall obtain at least a medium score from [Core Web Vitals](#).

5.1.1.1 Largest Contentful Paint (LCP): measure loading performance, LCP should occur within 2.5 seconds when the page first starts loading.

5.1.1.2 First Input Delay (FID): measures activity, FID should be less than 100ms.

5.1.1.3 Cumulative Layout Shift (CLS): measure visual stability, pages should maintain a CLS of 0.1 or less.

5.1.2 Load balancing solutions should be available to prevent system overload.

5.2 Accessibility

5.2.1 The system shall allow the user to use the application on any portable devices supporting web-based applications.

5.3 Software quality attributes

5.3.1 All system content shall be available in English.

5.3.2 All visible web page components shall have a responsive design that fits different screen sizes.

5.3.3 The developers shall troubleshoot problems faced by the users upon request.

5.3.4 The system shall be updated/maintained by the developers on a bi-weekly basis.

5.4 Security Requirements

5.4.1 The user's location data must be only used while the user is using the system.

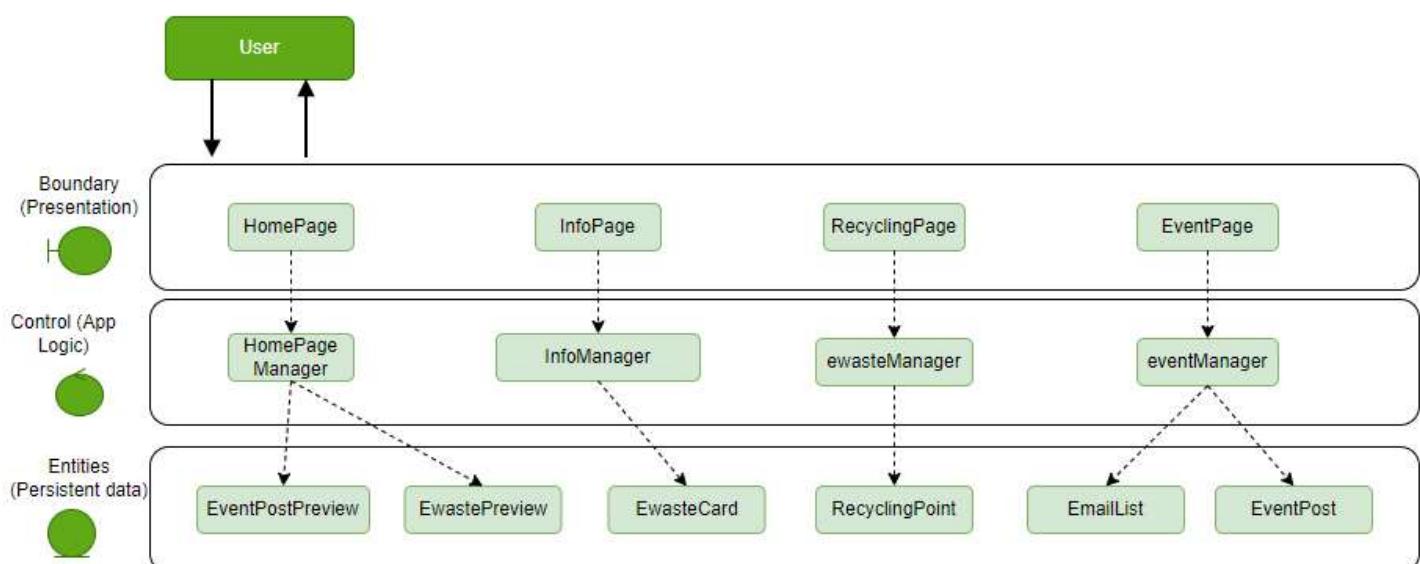
5.4.1.1 No location data shall be collected without the user's consent.

5.4.2 The user's email address must be only used for mailing purposes.

5.4.3 Email addresses shall not be shared with any other third parties.

6. Architecture Design

6.1 System Architecture



6.2 Design pattern

Problem: The code for representing e-cycling events and e-waste type is reused repeatedly. It will require repeat work in case of hard coding and using implementation.

Solution: Using interfaces enables programming to an abstraction. It allows programmers to make the coupling between classes loose since interfaces are crucial for inter-module communications. Furthermore, the use of interfaces follows the Object-Oriented programming principles, which are the Open-closed principle and dependency injection principle, which make code easier to test and extend.

6.2.1 Factory Pattern

A factory pattern is a creational pattern that uses factory methods to deal with the problem of creating objects without having to specify the exact class of the object that will be created. This is done by creating objects by calling a factory method - either specified in an interface and implemented by child classes, or implemented in a base class and optionally overridden by derived classes - rather than by calling a constructor.

In our application, some classes, such as EventPost and EventPostPreview are objects that share similar components. Hence, creating an interface, which is the Post interface, allows higher classes to instantiate concrete classes that implement the Post interface. In addition, there are E-waste Card objects on the info page that share the same functions. Hence, we use interfaces to optimize and keep our code clean as we can separate the concerns of different classes.

6.2.2 Strategy Pattern

Strategy pattern is a behavioral software design pattern that enables selecting an algorithm at runtime. Instead of implementing a single algorithm directly, code receives run-time instructions as to which in a family of algorithms to use.

In our application, some classes such as EventPost and E-wasteCard have a set of algorithms or objects that should be interchangeable. Therefore, strategy patterns will provide encapsulation, hide implementation and allow behavior change at runtime.

7. Testing

7.1 Black box testing

7.1.1 Get user location

- a) Display user's geolocation

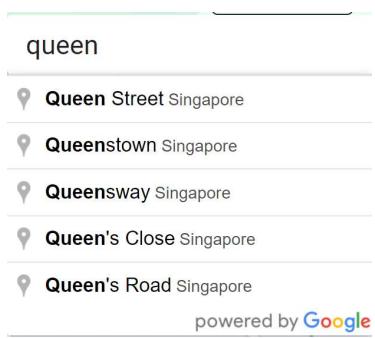
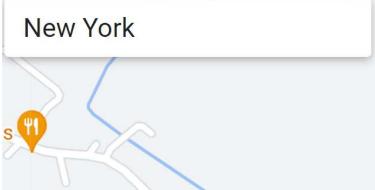
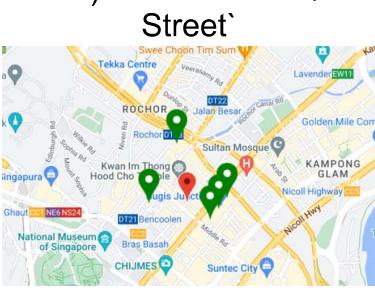
Test ID	Test input		Expected Result	Actual Result
	Latitude	Longitude		
01	1.348424	103.683385	Nanyang Technological University	Nanyang Technological University
02	1.298422	103.781643	National University of Singapore	National University of Singapore
03	1.363085	103.992354	Jewel Changi Airport	Jewel Changi Airport
04	1.308747	103.826403	Gleneagles Hospital	Gleneagles Hospital
05	1.319675	103.770718	Clementi Community Center	Clementi Community Center

b) Get user's current location

#	Scenario	Expected Result	Actual Result	Approval status
01	Location service not allowed	Warning pop up	Warning pop up	Yes
02	Location service not available	Warning pop up	Warning pop up	Yes
03	Location service is available	Map center to user ISP's location	Map center to user ISP's location	Yes

7.1.2 Autocomplete search box and navigator

#	Scenario Input	Result		Approval Status
		Expected	Actual	

01	User type in "queen"	Related places in Singapore will be displayed		Yes
02	User type in a place outside Singapore ("New York")	Nothing will be displayed		Yes
03	User type in "queen" and select 'Queen Street'	User current location (red marker) is moved to 'Queen Street'		Yes

7.1.3 Search filters

#	Input			Result		Approval status
	Location	Type	Range	Expected	Actual	
01	"City hall"	Ink and toner cartridges	500m	1 place with green markers are rendered	1 place with green markers are rendered	Yes
02	"City hall"	Ink and toner cartridges ICT equipments	500m	3 places with green markers are rendered	3 places with green markers are rendered	Yes

7.1.4 Subscribe to email

a) Generic cases

Test ID	Scenario	Expected Result	Actual Result
01	Input a valid email address	The system displays a notification of successfully subscribing	The system displays a notification of successfully subscribing
02	Input an invalid email address (does not contain '@' character)	The system displays a notification of invalid email and unsuccessfully subscribing	The system displays a notification of invalid email and unsuccessfully subscribing
03	Input a duplicate email address (Existing email address in the mailing list)	The system displays a notification of duplicate email and a welcome back message	The system displays a notification of duplicate email and a welcome back message

b) Specific cases (Email address)

Test ID	Email	Expected Result	Actual Result
01	onestop@email.com	Subscribe successfully! Welcome on board	Subscribe successfully! Welcome on board
02	onestop	Please include an '@' in your email address. 'Onestop' is missing an '@'.	Please include an '@' in your email address. 'Onestop' is missing an '@'.
03	onestop@email.com	Email already existing. Welcome back!	Email already existing. Welcome back!

7.2 White box testing

7.2.1 Control flow testing: Email subscribing

Method: inputEmail()

Parameter: email

Return: boolean

Purpose: subscribing email to the mailing list for updated events.

Cyclomatic complexity:

$$[\text{Conditions} + 1] = [2 + 1] = 3$$

$$[\text{Edges} - \text{Nodes} + 2] = [8 - 7 + 2] = 3$$

Basis paths:

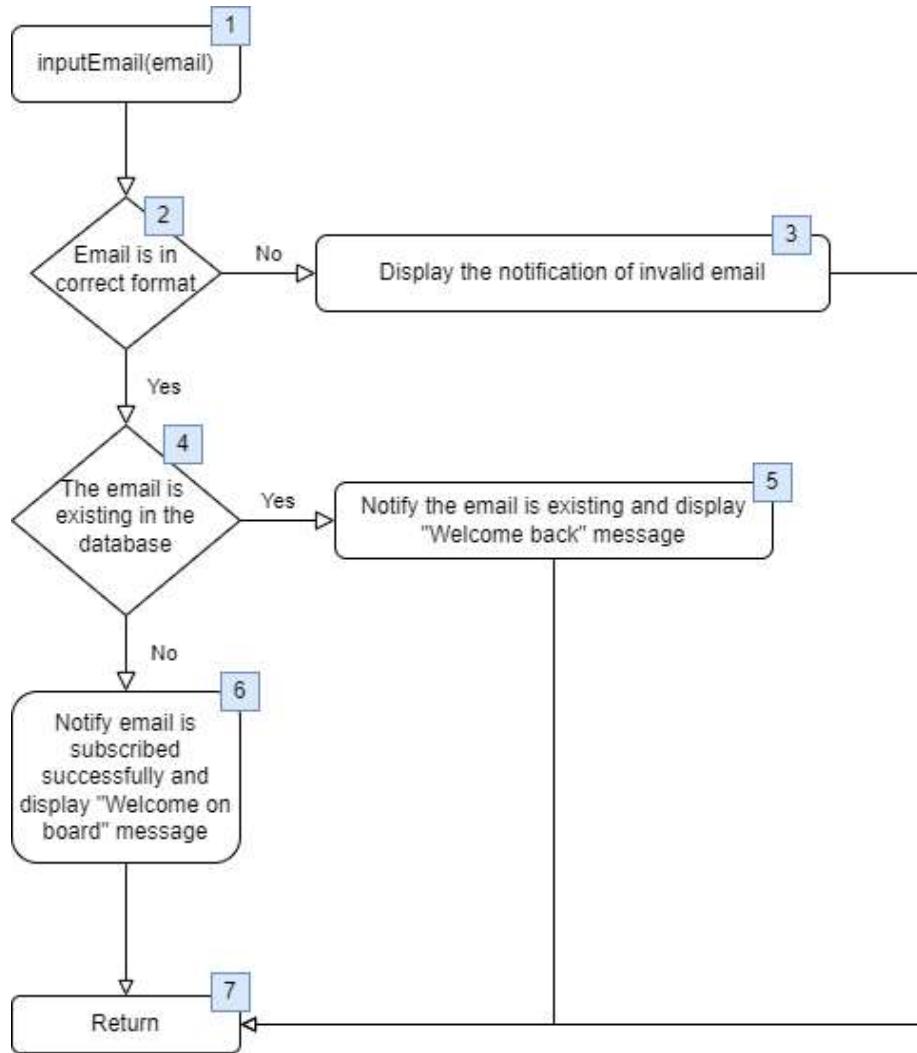
- 1) 1, 2, 4, 6
- 2) 1, 2, 3
- 3) 1, 2, 4, 5

Test cases:

- 1) User inputs a valid email (including the '@' character) and the input email does not exist in the database.
- 2) User inputs an invalid email (does not include the '@' character).
- 3) User inputs a valid email (including the '@' character) and the input email exists in the database.

Executing paths:

- 1) 1, 2, 4, 6
- 2) 1, 2, 3
- 3) 1, 2, 4, 5



7.2.2 Control flow testing: Find E-waste recycling points

Method: `FindRecyclingPoints()`

Parameter: `userLocation`, `typeOfEwaste`, `range`

Return: Boolean

Purpose: Searching for the recycling locations for chosen types of E-waste within a specified range, displaying detailed information of the recycling location.

Cyclomatic complexity:

$$[\text{Conditions} + 1] = [4 + 1] = 5$$

$$[\text{Edges} - \text{Nodes} + 2] = [17 - 14 + 2] = 5$$

Basis paths:

1) 1, 2, 3, 5, 6, 8, 9, 11, 12, 13, 14

2) 1, 2, 4, 5, 6, 8, 9, 11, 12, 13, 14

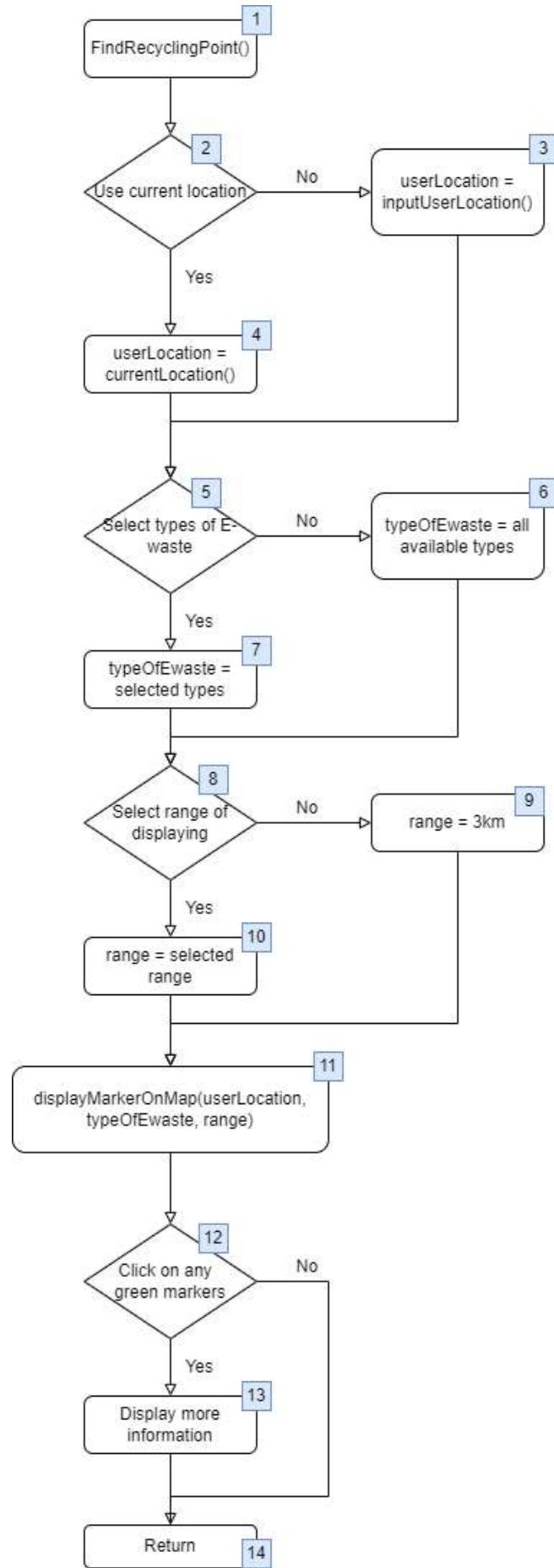
- 3) 1, 2, 3, 5, 7, 8, 9, 11, 12, 13, 14
- 4) 1, 2, 3, 5, 6, 8, 10, 11, 12, 13, 14
- 5) 1, 2, 3, 5, 6, 8, 9, 11, 12, 14

Test cases:

- 1) User searches for recycling points that accept any type of E-waste within a default 3km from the user's current location, and chooses a location point to display the specific information.
- 2) User searches for recycling points that accept any type of E-waste within a default 3km from the input location, and the user chooses a location point to display the specific information.
- 3) User searches for recycling points that accept specified types of E-waste within a default 3km from the user's current location, and chooses a location point to display the specific information.
- 4) User searches for recycling points that accept any type of E-waste within a specified range from the user's current location, user chooses a location point to display specific information.
- 5) User searches for recycling points that accept any type of E-waste within a default 3km from the user's current location, and does not choose a location point to display specific information.

Executing paths:

- 4) 1, 2, 3, 5, 6, 8, 9, 11, 12, 13, 14
- 5) 1, 2, 4, 5, 6, 8, 9, 11, 12, 13, 14
- 6) 1, 2, 3, 5, 7, 8, 9, 11, 12, 13, 14
- 7) 1, 2, 3, 5, 6, 8, 10, 11, 12, 13, 14
- 8) 1, 2, 3, 5, 6, 8, 9, 11, 12, 14



7.2.3 Control flow testing: Display information by type of E-waste

Method: displayInformation(type)

Parameter: type

Return: void

Purpose: Display information according to the E-waste type

Cyclomatic complexity:

$$[\text{Edges} - \text{Nodes} + 2] = [6 - 5 + 2] = 3$$

Basis paths:

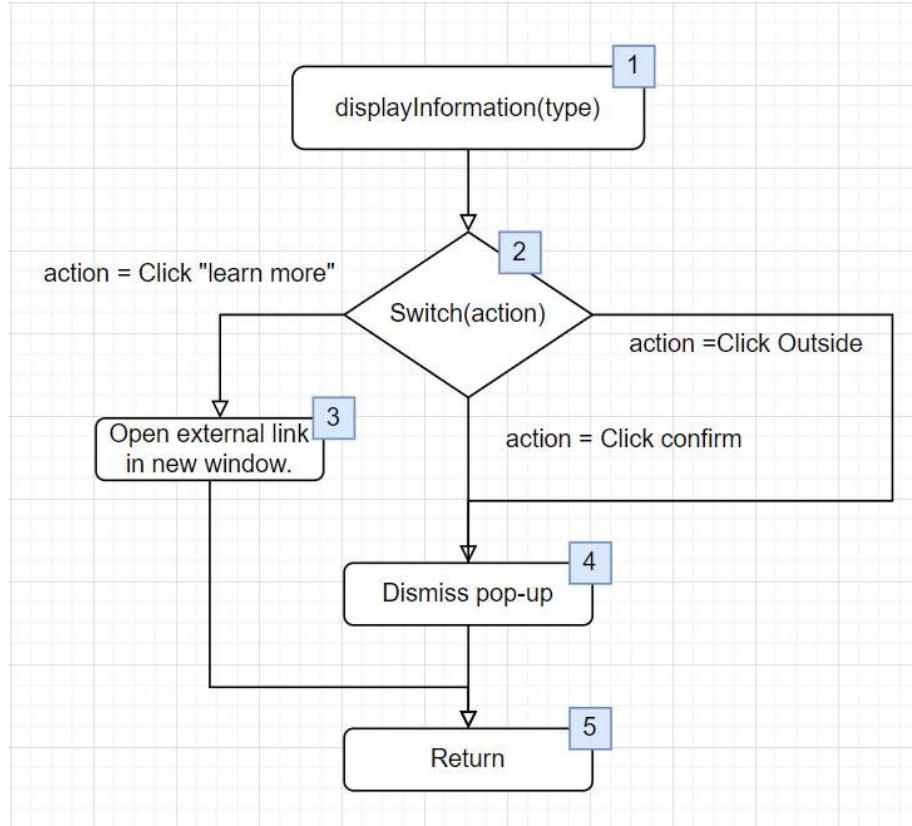
- 1) 1, 2, 3, 5
- 2) 1, 2, 4, 5
- 3) 1, 2, 4, 5

Test cases:

- 1) User clicks on “Learn more” to read more information about the input E-waste type
- 2) User clicks on “Confirm” after finish reading information about the input E-waste type
- 3) User clicks outside the popup box to finish reading information about the input E-waste type

Executing paths:

- 1) 1, 2, 3, 5
- 2) 1, 2, 4, 5
- 3) 1, 2, 4, 5



7.2.4 Control flow testing: Access event information

Method: `accessEventInfo(event_url)`

Parameter: `event_url`

Return: void

Purpose: access event information regarding E-waste recycling in Singapore.

Cyclomatic complexity:

$$[\text{Edges} - \text{Nodes} + 2] = [5 - 5 + 2] = 2$$

Basis paths:

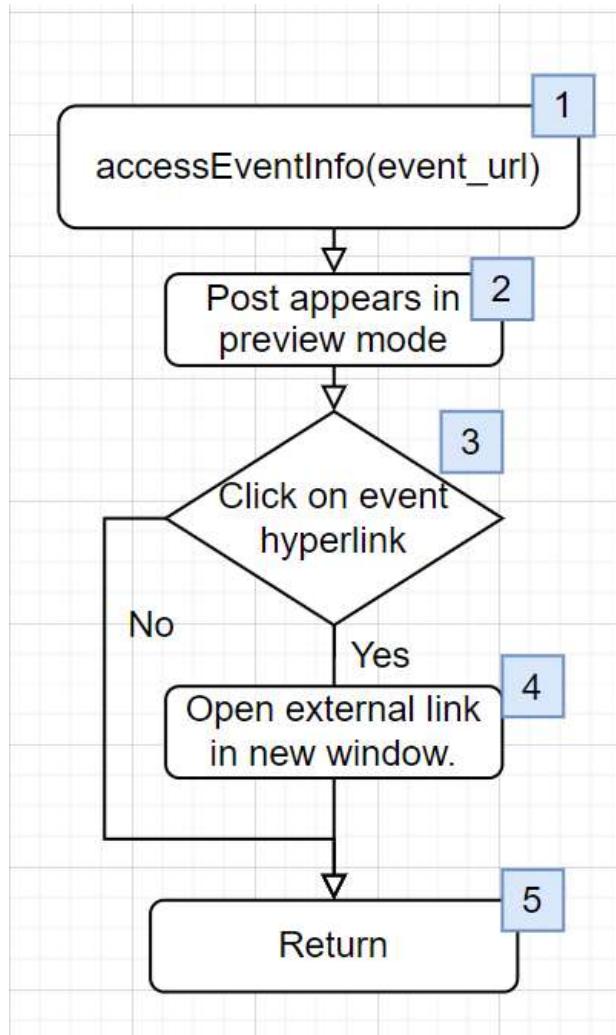
- 1) 1, 2, 3, 4, 5
- 2) 1, 2, 3, 5

Test cases:

- 1) User clicks on "Learn more" to read more information about the input E-waste type
- 2) User clicks on "Confirm" after finish reading information about the input E-waste type

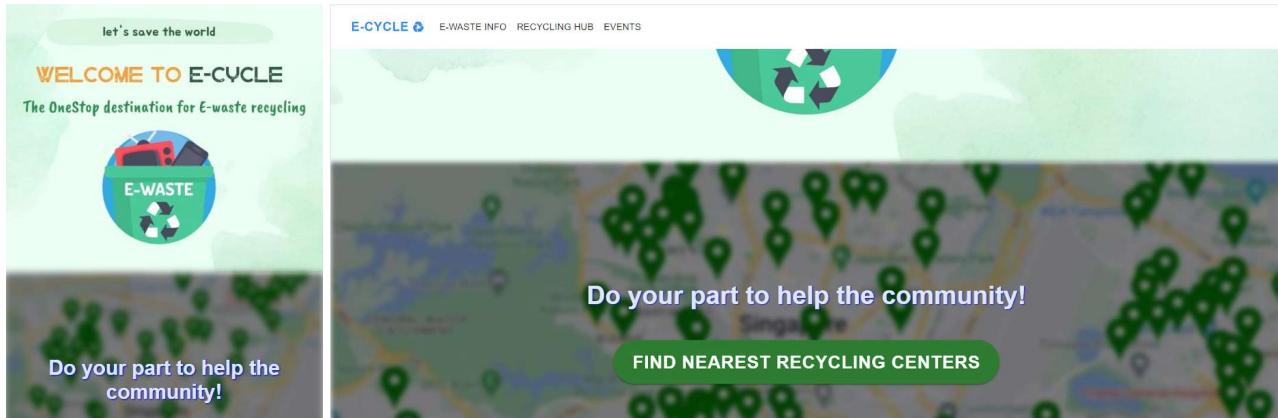
Executing paths:

- 1) 1, 2, 3, 4, 5
- 2) 1, 2, 3, 5



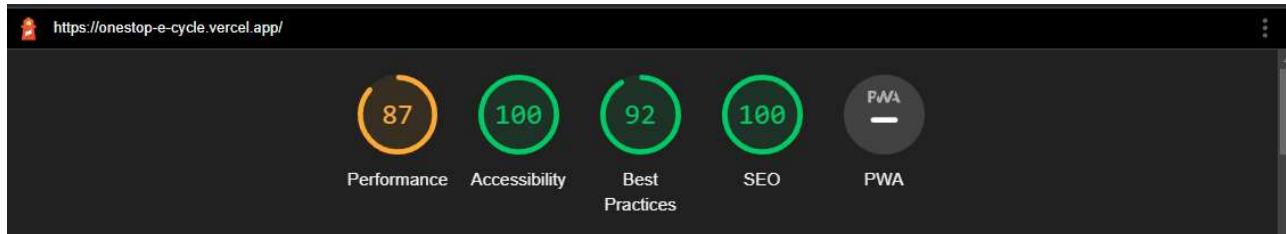
7.3 Other testing

7.3.1 Responsive design

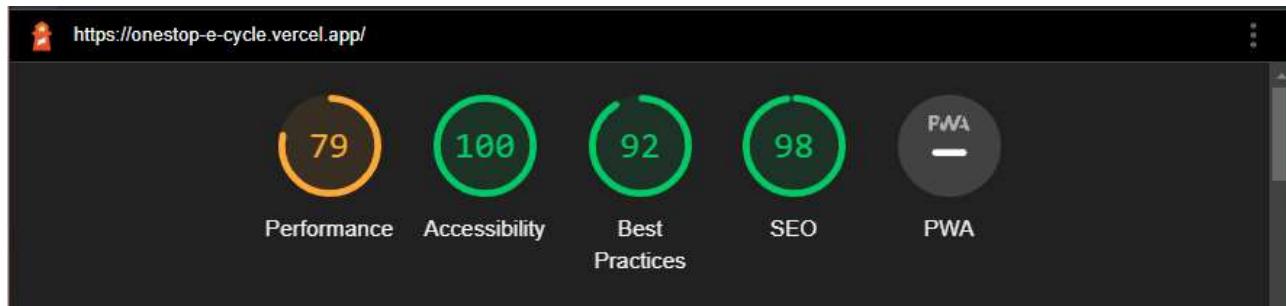


(Home page, at route “/”
 mobile view vs desktop view
 Host at: <https://onestop-e-cycle.vercel.app/>)

7.3.2 Performance



(At route “/”, Lighthouse’s **desktop mode**
 Chrome version **100.0.4896.88**, incognito mode with 0 extension)



(At route “/”, Lighthouse’s **mobile mode**
 Chrome version **100.0.4896.88**, incognito mode with 0 extension)

7.3.3 Single Page Application Behavior

To achieve this, our application adopts a client-side framework with UI data binding. The controller and model state are maintained within the client browser. Therefore, new pages are capable of being generated without any interaction with the server.

(visit: <https://onestop-e-cycle.vercel.app/>, click on any internal link)

8. Future work

8.1 Maintenance

- **Corrective maintenance:** detect and correct bugs while using the software, or enhance the performance of the system.
- **Adaptive maintenance:** adapt to new operating systems, new software and hardware environments. For the purpose of extending to mobile-based applications, adaptive maintenance is needed to be taken.

- **Perfective maintenance:** support new features or modification of current feature to align with customers' requirements.
- **Preventive maintenance:** modify and optimize the codebase to prevent future problems of the software.

8.2 Future work

1) Cover other types of waste, such as plastic waste, and organic waste

- Purpose: target other types of waste, which are even more popular, make our application a one-stop platform for all waste.
- Actions in need:
 - Have more data of different waste types.
 - Software maintenance action is needed to modify our system.

2) Extend the cover range to different ASEAN countries

- Purpose: improve recycling rates in other countries, particularly ASEAN countries, where the amount of waste generated every year is very high compared to other regions.
- Actions in need:
 - Collaborate with organizations or governments to access the target countries' e-waste data.
 - Software maintenance action is needed to modify our system.

3) Point and reward system

- Purpose: encourage more people to use our system and recycle more.
- Actions in need:
 - Modify our system to have users and accounts, where users' points are converted into vouchers.
 - Collaborate with sponsorship companies and supermarkets to provide vouchers.

4) Recycling service for business and organization

- Purpose: as businesses and organizations may produce a large amount of e-waste, we build a special service to adapt to the business and organizations' recycling needs.
- Actions in need:
 - Software maintenance action is needed to modify our system.