E-cycled
by
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ABSTRACT

E-waste is a global problem that is growing at an amazing pace, going from 41.4 million metric tonnes (Mt) to 44.7 Mt in just 3 short years. With the amount of devices that are being released each month it's easy to forget the impact it can have. Our undertaking is to create a more accessible method of disposing and tracking unwanted or outdated devices. We plan to accomplish this with a frictionless web application that will allow anyone to recycle their goods using a painless and effecticient pickup system which is both secure and speedy. We will create and test the web app to show both the pickup and delivery of an item as well as safe methods to secure or destroy any unwanted data.

1. INTRODUCTION

The following sections will introduce the problem we intend to solve and give an overview of our proposed solution.

1.1 Introduction

The average consumer lacks knowledge about what electronics in their house can be recycled when the product is worn out and no longer able to be used. From clothes washing machines to hair dryers to laptops and everything between can and should be recycled to help preserve our Earth's resources and to stop the effects of climate change. We believe that we can help the world come one step closer to solving our environmental crisis by educating and connecting people to resources that will help them recycle things around their house that they no longer have a use for.

1.2 Problem

Not only is there a problem with a lack of recycling, there is a lack of reporting: "Less than 20% of e-waste is formally recycled, with 80% either ending up in landfill or being informally recycled"[2] This tells us that a staggering number of the waste that is recycled is done in a safe, trackable manner. If big consumer technology manufacturers like General Electric and Apple took more initiative in tracking where their product ends up at the end of its life then maybe it would be easier to be sure that as much waste as possible is ending up in recycling facilities instead of landfills. Even if the products end up being recycled, it is often, 80%, in developing parts of the world where contact with hazardous materials causes health defects in workers.[1]

1.3 Solution

E-Cycled is our initiative to offer an application that will connect those with unwanted electronics to information and a pick-up service. Our website will be a tool that helps a user figure out what kind of waste they have through a wiki. The wiki also provides resources and information about the potential dangers of recycling their items (environmental and personal if it is computer related) as well as existing solutions for recycling a particular item, if it would be more efficient to use that service. If a user wishes to use our service, they can provide their location and then our app will assign a driver to make the pick-up. The user will be sent information about the scheduled pick-up of their recyclable. It is up to the user how much information they would like to see from the app. There will be opportunities at multiple points in the app's function that the user can take to find more out about a certain topic, such as, how much impact their recycled item had on the environment and how you might qualify for the manufacturer to recycle the item for you free of charge.

1.4 Project Goals

The goals of *E-cycled* are to connect users with education and solutions to their electronic waste recycling needs. Along with this goal we hope to help solve the environmental crisis not only by recycling more precious metals and properly disposing of toxic materials but by collecting data for environmental researchers and recycling facilities in the area and around the world. We aim to accomplish this by employing a web app that can be accessed from desktop or mobile and quickly connect users with their e-waste resources.

1.5 Overview

Throughout this final report, there will be information on how the project was completed. The report includes in-depth processes and includes the following sections: design objectives, methodology, budget, timeline, problems encountered, and future recommendations.

2. DISCUSSION

In the following section we will elaborate on the technical specifications of our project as well as the implementation of our product.

2.1 Project Concept

In a brainstorming session the team was discussing areas in technology that are contributing to our climate crisis because of a lack of education or a lack of profit to be made in the space. That's when we stumbled across the issue of how to properly dispose of computers and other electronics related waste. This is an area that we found heavily contributes to greenhouse gases and other forces potentially detrimental to human civilization. The problem is there and some technology is reclaimed, like smart phones, but others are thrown by the wayside because there is no profit to be made off the resources than to mine for new ones. The technology scrapping industry would stand to benefit from an increased supply. As of now, most hard drives and computer parts get thrown away in the garbage which causes environmental hazards and wastes money.

2.2 Design Objectives

The team's initial plan for the setup and infrastructure of our application slowly transitioned to a different approach on multiple levels. Initially, we were planning on managing our full stack and backend on Azure while using a web app service like WordPress or Wix to build out our site. As we progressed our planning and wireframing we were closer to standing up our application and discovered that those services would not fit our needs exactly. We found that trying to incorporate code generated with Wix we would have to understand how Wix integrates with external APIs and how we would configure the backend. That not being an option our new

goals shifted to be hosting a LAMP stack (Linux, Apache, MySQL and PHP) on AWS with a packaged version of the Drupal web app managed by Bitnami. The MySQL database will be used for core functionality of the site such as storing queued items and user profiles.

2.3 Methodology and Technical Approach

Hosting

Our stack will be hosted on Amazon Web Service's (AWS) Lightsail virtual private server service. AWS offered the best option for both lightweight application development as well as development integration. Though we initially planned to us Microsoft Azure, building the site proved to be more straightforward using the Lightsail option under AWS. Hosting on AWS is not only scalable but also allows for simple administration that can be handled with a Graphical User Interface(GUI) or command line.

Web Server/Web Application

The Web server itself is a LAMP stack (Linux, Apache, MariaDB, PHP) that has been simplified to launch with preconfigured dependencies. Lightsail also included a function to launch our site with a customizable template using Bitnami as medium to run Drupal. This allows for faster production and saves a lot of time with developer operations.

Database/Linux Backend

The database is a preconfigured instance of MariaDB(MySQL) on top of a Redhat instance of Linux. This allows for running more common bash scripts and allows for better version control as everything is tested before the stack is built. We opted for the Linux operating system as it is not only a cheaper option but also has a large pool of knowledge and resources for

support. MariaDB(MySQL) offers many similar benefits as it is also open-source with an affordable enterprise option compared to SQLserver which charges by the connection.

2.4 User Profile

Table 1: User Profile Form 1 *The following table demonstrates the first group of users we anticipate, the administrators.*

User Profile Form 1
Application: MongoDB, Google Maps API, Angular 2, Bootstrap, HTML5, CSS3, Microsoft Azure
Potential Users: Web developers/administrators
Software and Interface Experience: The user should be able to navigate GUI development tools as well as command prompt and use some database commands.
Experience with Similar Applications: Previous experience with high level languages and an understanding of the DOM is crucial to a user's interaction. Experience with version control and collaboration tools will be necessary.
Task Experience: Applying the knowledge and learning how to operate the tools required to launch the webapp as well as initiate changes.
Frequency of Use: Administrators will only have to interact with the webapp during the initial development depending on the webapp lifecycle. Most updates will concern break-fix and back-end efficiency as well as security.
Key Interface Design Requirements that the Profile Suggests: The interface design will not affect administration as much as the interaction with the aforementioned tools is the most critical in their responsibility.

Table 1: User Profile Form 1

Table 2: User Profile Form 2 *The following table demonstrates the first group of users we anticipate, the user looking for recycling info.*

User Profile Form 2
Application: e-Cycle
Potential Users: Recycling User

Software and Interface Experience: The user should have experience with ordering something online as well as tracking apps. Being able to use Google maps will also be a requirement.
Experience with Similar Applications: Wikipedia, Domino's tracker, UPS tracker
Task Experience: Basic web page interaction with button-click, sign-ons and the ability to navigate search bars.
Frequency of Use: The user will access the app when they have to look up nearby e-waste locations, track drop-off/pick-up or schedule a new pick-up. The access could be hourly to daily to weekly.
Key Interface Design Requirements that the Profile Suggests: The flow of the website should follow modern conventions and abide by accessibility standards to allow for a broader audience.

Table 2: User Profile Form 2

Table 3: User Profile Form 3 *The following table demonstrates the first group of users we anticipate, driver/pick up agent.*

User Profile Form 3
Application: e-Cycle
Potential Users: Driver/Pick up agent
Software and Interface Experience: Drivers should have some experience with navigating apps and following prompts. Mostly web app or phone app experience for navigating the interface.
Experience with Similar Applications: Doordash, Uber Eats, Amazon Local Delivery
Task Experience: Drivers should be able to monitor the web app for incoming deliveries that they will be able to choose from based on proximity and object size limitation.
Frequency of Use: Drivers will have to check the app frequently when making deliveries, 3-4 times every hour when they are available otherwise, they will only have to access weekly for payout.
Key Interface Design Requirements that the Profile Suggests: The interface will have to be easy to use and quickly update so the driver can quickly respond to deliveries. Minimizing the amount of manual interactions will be crucial to the driver's success.

Table 3: User Profile Form 3

2.5 Use Case Diagram

Figure 1: Use Case Diagram *The following diagram, Figure 1, demonstrates the use case for E-cycled. The diagram shows all possible users with corresponding tasks.*

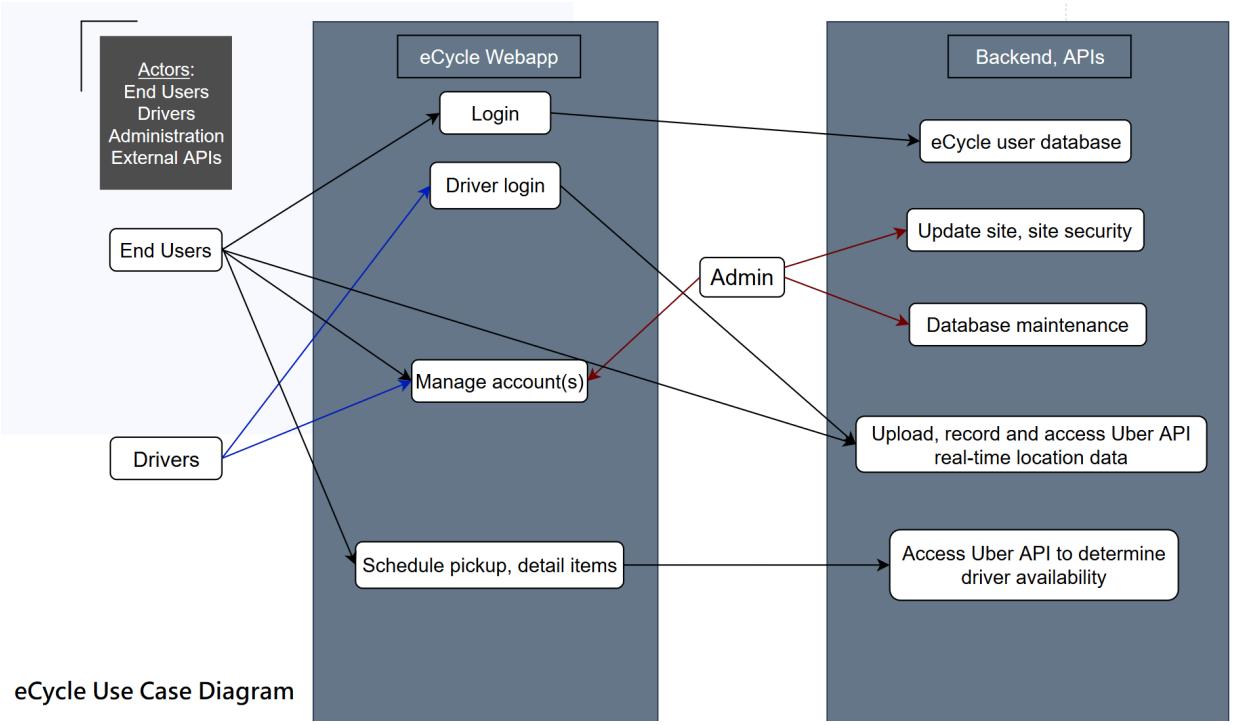


Figure 1: Use Case Diagram

2.6 Testing

The following information details the plan for testing the E-cycled application. Testing is a valuable part of software development and enables our group to modify parts of the project that didn't function as expected.

Testing Methodology

The team chose to test the site by having each of our different types of users perform various navigation and interaction tasks with the site. We were able to improve the user interface by running unit tests. This tested the overall functionality of the site to maintain quality whilst implementing new features. Our team used a content management system called Drupal to handle the majority of security and compatibility concerns.

Scope of Testing

Basic site navigation - Given multiple tasks involved with basic site functionality and navigation.

Submitting an order - We chose to test this portion of the site because it is the main goal of our project. We want to ensure that our site guides the user to creating an account successfully.

Account functionality - Account creation, login, forgot password

Objectives

a. All major features are accounted for

b. All navigation should complete successfully

c. All bugs need to be resolved before presentations

Test Results

We conducted various unit tests to continuously improve the usability of the site. After running our first few unit tests we concluded that the main pages layout needed updating so that users and drivers could navigate to the forms easier. Running a few security tests was necessary to ensure that the site's groups were defined appropriately. As most of the technical functions were managed by Drupal we were able to focus more on the usability aspect of the website as well as the access management.

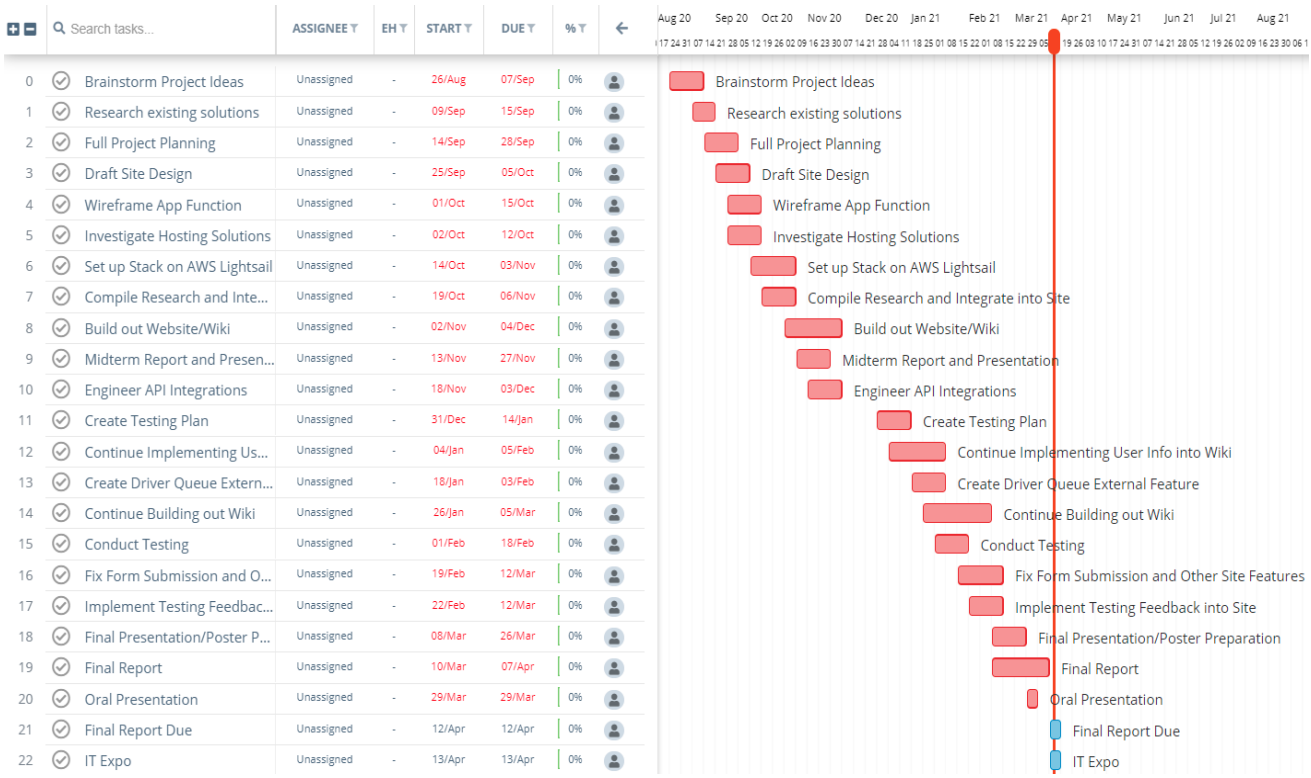
2.7 Problems Encountered and Analysis of Problems Solved

One problem the E-cycled team ran into when trying to set up our web app was related to the budget. We discussed as a team how much we would be comfortable spending to make sure this project is as good and complete as it can be without suffering too much from lack of capability and resources. To solve this problem we did extensive research into all of our options for hosting our web app. After discussing hosting it on a home server or one of our machines, hosting it in a cloud provider like GCP, Azure or AWS and hosting it through a website hosting service like Wix or WordPress. At the end of the day, we found the option that would give us the customization and configuration of our whole stack while staying cost effective and that was AWS's Lightsail combined with Drupal.

Another problem we encountered had to do with communication and scheduling within the group. In the beginning of the semester we had some hiccups caused by group members not being on the same page and not being able to find ample time to meet. This was dealt with in stride with ensuring we kept each other updated through our group messaging app, Telegram, Google Drive, Figma and other platforms that allowed for real-time collaboration, and Taiga.io taskboarding. We also found times throughout the week aside from Monday night to meet on Teams.

2.8 Project Timeline

Table 4: Project Timeline *The following table details the start and end date of each of our major tasks accomplished so far.*



	Search tasks...	ASSIGNEE	EH	START	DUE	%
0	Brainstorm Project Ideas	Unassigned	-	26/Aug	07/Sep	0%
1	Research existing solutions	Unassigned	-	09/Sep	15/Sep	0%
2	Full Project Planning	Unassigned	-	14/Sep	28/Sep	0%
3	Draft Site Design	Unassigned	-	25/Sep	05/Oct	0%
4	Wireframe App Function	Unassigned	-	01/Oct	15/Oct	0%
5	Investigate Hosting Solutions	Unassigned	-	02/Oct	12/Oct	0%
6	Set up Stack on AWS Lightsail	Unassigned	-	14/Oct	03/Nov	0%
7	Compile Research and Inte...	Unassigned	-	19/Oct	06/Nov	0%
8	Build out Website/Wiki	Unassigned	-	02/Nov	04/Dec	0%
9	Midterm Report and Presen...	Unassigned	-	13/Nov	27/Nov	0%
10	Engineer API Integrations	Unassigned	-	18/Nov	03/Dec	0%
11	Create Testing Plan	Unassigned	-	31/Dec	14/Jan	0%
12	Continue Implementing Us...	Unassigned	-	04/Jan	05/Feb	0%
13	Create Driver Queue Extern...	Unassigned	-	18/Jan	03/Feb	0%
14	Continue Building out Wiki	Unassigned	-	26/Jan	05/Mar	0%
15	Conduct Testing	Unassigned	-	01/Feb	18/Feb	0%
16	Fix Form Submission and O...	Unassigned	-	19/Feb	12/Mar	0%
17	Implement Testing Feedbac...	Unassigned	-	22/Feb	12/Mar	0%
18	Final Presentation/Poster P...	Unassigned	-	08/Mar	26/Mar	0%
19	Final Report	Unassigned	-	10/Mar	07/Apr	0%
20	Oral Presentation	Unassigned	-	29/Mar	29/Mar	0%
21	Final Report Due	Unassigned	-	12/Apr	12/Apr	0%
22	IT Expo	Unassigned	-	13/Apr	13/Apr	0%

Table 4: Project Timeline

2.9 Project Budget

Table 5: Project Budget *The following table details the financial expenditures and investments made towards the project.*

Ecycled

Web Site Budgeting Tool

12/7/2020

Gray cells contain calculations that should not be altered.

Company Data	Rate
Required rate of return	10%
Tax rate	30%

Initial Investment in Web Site	YEAR	1	2	3
Hardware (e.g., servers)	$0.00			
Software (e.g., e-commerce catalog software)	$200.00			
Development (e.g., third-party site design and development)	$300.00			
Total Initial Investments	**$500.00**			

Benefits from Web Site	YEAR	1	2	3
Grants		$50,000.00	$0.00	$0.00
Electronic part sales		$2,000.00	$2,000.00	$2,000.00
Private Donations		$50.00	$50.00	$50.00
Total Benefits		**$52,050.00**	**$2,050.00**	**$2,050.00**

Costs (Excluding Initial Capital Investments)	YEAR	1	2	3
Driver fuel re-inbursement		$300.00	$300.00	$300.00
Maintenance		$75.00	$75.00	$75.00
Project management, customer support		$228.00	$228.00	$228.00
Depreciation on capital expenditures (calculation uses three-year period)		$166.67	$166.67	$166.67
Total Costs		**$769.67**	**$769.67**	**$769.67**

Totals	YEAR	1	2	3
Net Benefits (Costs)		$51,280.33	$1,280.33	$1,280.33
Tax		$15,384.10	$384.10	$384.10
Value after tax		$35,896.23	$896.23	$896.23
Depreciation added back		$166.67	$166.67	$166.67
Cash flow	-$500.00	$36,062.90	$1,062.90	$1,062.90
Cumulative cash flow	-$500.00	$35,562.90	$36,625.80	$37,688.70

Evaluation Metrics	
Net present value (NPV)	$33,961.46
Internal rate of return (IRR)	7115.57%
Payback period (in years)	0.01

Table 5: Project Budget

2.10 Recommendations for Improvement

The team learned a lot in the process of creating E-cycled and have many things that we could improve if pursuing another similar project in the future. First, we would have picked a different platform to create the web app on. Drupal and Bitnami are great offerings for many different types of projects, but had considerable weaknesses when we attempted to use it for E-cycled. We enjoyed the templates and assistance from the service when creating static pages but ran into issues when trying to incorporate our own code and modules into the site. This hindered us from being able to incorporate google maps tracking for the drivers and to do all that we envisioned for the pickup form submission.

Another aspect of the project that could have been approached differently was planning. This ties into our first recommendation in that we could have spent more time planning and researching which technology to use, but we could have taken more time to plan in other ways as well. With different schedules, it was hard to find time to plan out times throughout the semester to work. We eventually overcame this with being flexible with our established meeting times and working asynchronously.

If we had more time and resources to continue the project we have a few things in mind that we would like to accomplish. We would like to incorporate Google Maps tracking and a built in estimator into the pickup process. We would also like to add a more intuitive way to navigate throughout the app, built like a restaurant menu based on the type of waste a person has, with pictures and descriptions to help the user.

3. CONCLUSION

The following section will enumerate what was learned by the team and next steps in development.

3.1 Lessons Learned

Our team had no shortage of lessons learned at this point in the development of our project. Choosing technologies to host and run our web app that were easy to maintain and affordable was a major concern of ours in the beginning. We learned that it would have been best to pick the technologies we intended to use and start the work on them rather than deliberating on which solution we were going to use. We also learned that preparation was key. Our team could have been more prepared coming into meetings with our advisor and with each other to make sure that we made the most of everyone's limited time. Making contact with the existing businesses and nonprofits who work with electronics recycling in the area has proven to be a challenge and we have learned lessons in persistence and professional communication reaching out to them.

3.2 Abilities and Skills Developed Throughout Project

Starting off the year, we knew we would have our work cut out for us doing a project centered around a web app with only one of our three group members having prior experience in full stack development, the other two being cybersecurity majors with co-op experience only on operations focused teams. This being said, we practiced "on-the-job" training in full stack development, app design and cloud platform management. We all learned aspects of project management and communication in this new work from home environment. We grew a lot as a group and will take the skills we gathered here on in our careers.

REFERENCES

4.1 References

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Nijman, S. (2019, January 24). UN report: Time to seize opportunity, tackle challenge of e-waste. Retrieved November 07, 2020, from https://www.unenvironment.org/news-and-stories/press-release/un-report-time-seize-opportunity-tackle-challenge-e-waste