BLOCKCHAIN BASED CUSTOMER LOYALTY PROGRAM IN MALAYSIA APPAREL INDUSTRY

By

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ABSTRACT

This project is a Blockchain-based apparel customer loyalty program design project for academic purposes. The project will provide a more customer-centric customer loyalty program such as more control over their data, secure payment methods, alternative ways of obtaining and using loyalty points, and higher transparency on apparel product information. In traditional customer loyalty programs, customers may face problems such as their data being breached by malicious criminals due to the organization that owned their data has not secured their database well. Also, customers have a high chance of being scammed by online shopping because the funds are directly transferred to the seller's account. Besides, the loyalty points that are owned by customers are bound to the business, which is not flexible and not attractive to customers. Also, the apparel product information is not transparent enough. Although most of the organizations have provided features such as the material used, the sourcing such as labour conditions is still unknown to customers. By implementing Blockchain, these problems can be solved. For the system design, the methodology that will be used in this project is Test Driven Development (TDD), this methodology forces solo developer to define specific test cases before writing code, which helps developer to gain a clear understanding of the requirements and expected behaviour of the project. The hardware involved in this project is a laptop, and software and technologies will be used including Ethereum Sepolia Testnet, Remix IDE, MetaMask, Node.js, Pinata, Firebase, Alchemy, Solidity and Visual Studio Code. The final deliverable of this project is a server-side web application of an apparel customer loyalty program that is enhanced with Blockchain.

TABLE OF CONTENTS

TITLE PAGE i

REPORT STATUS DECLARATION FORM ii

FYP THESIS SUBMISSION FORM iii

DECLARATION OF ORIGINALITY iv

ACKNOWLEDGEMENTS v

ABSTRACT vi

TABLE OF CONTENTS vii

LIST OF FIGURES ix

LIST OF TABLES xiv

LIST OF ABBREVIATIONS xvi

CHAPTER 1: Introduction 1

1.1 Problem Statement and Motivation 1

1.2 Research Objectives 3

1.3 Project Scope and Direction 5

1.4 Contributions 6

1.5 Project Background 6

1.6 Report Organization 8

CHAPTER 2: Literature Reviews 9

2.1 Review of technology used 9

2.1.1 Blockchain 9

2.1.2 Smart Contract and Solidity 11

2.1.3 Remix IDE 12

2.1.4 Ethereum Sepolia Testnet 12

2.1.5 Google Firebase 13

2.1.6 MetaMask 13

2.1.7 Pinata 14

2.1.8 JavaScript, HTML and CSS 15

2.1.9 Node.js 15

2.1.10 Express.js 16

2.1.11 Pug.js 16

2.1.12 Web3.js 17

2.1.13 Babelify 17

2.1.14 Nodemon and Watchify 18

2.1.15 Alchemy 18

2.2 Review of the Existing Apparel Customer Loyalty Program in Malaysia 21

2.2.1 Customer Loyalty Program 21

2.2.2 Whimsigirl 21
2.2.3 TNTCO 22
2.2.4 ANAABU 23
2.2.5 Pestle & Mortar Clothing 24
2.3 Critical Remarks of previous work 25

CHAPTER 3: System Methodology/Approach 26
3.1 Design Specifications 26
3.1.1 Methodology 26
3.2 System Design Diagram 27
3.2.1 System Architecture Diagram 27
3.2.2 Use Case Diagram and Description 28
3.2.3 Activity Diagram 33
3.3 System Pre-Authoring Analysis 41

CHAPTER 4: System Design 45
4.1 Flowchart 45
4.2 System Components Specifications 46

CHAPTER 5: System Implementation 49
5.2 Software setup 49
5.2.1 Visual Studio Code 49
5.4 System Operation (with Screenshot) 54
5.5 Timeline 74

CHAPTER 6: System Evaluation and Discussion 75
6.1 Testing Setup and Result 75
6.2 Project Challenges 88
6.3 Objectives Evaluation 89

CHAPTER 7: Conclusion and Recommendation 90
7.1 Conclusion 90
7.2 Recommendation 92

REFERENCES 93

APPENDIX A-1
System Pre-authoring Google Survey Questions A-1

WEEKLY REPORT B-1

POSTER C-1

PLAGIARISM CHECK RESULT D-1

CHECKLIST FOR FYP2 THESIS SUBMISSION E-1

LIST OF FIGURES

Figure Number	Title	Page
Figure 2.1.1	The difference between centralized and decentralized networks	9
Figure 2.1.2	How Blockchain Works	10
Figure 2.1.3	Breakdown by Smart Contract Languages	11
Figure 2.1.4	Traditional App Development vs. Firebase App Development	13
Figure 2.1.5	MetaMask Architecture	14
Figure 2.1.6	Difference between HTTP and IPFS	14
Figure 2.1.7	Node.js System Architecture	15
Figure 2.1.8	Expree.js process	16
Figure 2.1.9	Template Engine	16
Figure 2.1.10	Communication channel between Developer and Blockchain	19
Figure 2.2.2.1	CLP page of Whimsigirl	22
Figure 2.2.3.1	CLP page of TNTCO	22
Figure 2.2.4.1	CLP page of ANAABU	23
Figure 2.2.5.1	CLP page of Pestle & Mortar Clothing	24
Figure 3.1.1.1	How TDD Works	26
Figure 3.2.1.1	System Architecture Diagram of proposed CLP	27
Figure 3.2.2.1.1	Use Case Diagram of proposed CLP	28
Figure 3.2.3.1	Activity Diagram of Customer Login Account	33
Figure 3.2.3.2	Activity Diagram of Purchasing Product	34
Figure 3.2.3.3	Activity Diagram of Redeeming Loyalty Reward	35

Figure 3.2.3.4	Activity Diagram of Viewing FAQ	36
Figure 3.2.3.5	Activity Diagram of Viewing Product Information	37
Figure 3.2.3.6	Activity Diagram of Viewing Purchasing History	38
Figure 3.2.3.7	Activity Diagram of Activity Diagram of Login Administrator Account	39
Figure 3.2.3.8	Activity Diagram of Configuring Website	40
Figure 3.3.1	Survey Question 1	41
Figure 3.3.2	Survey Question 2	41
Figure 3.3.3	Survey Question 3	41
Figure 3.3.4	Survey Question 4	42
Figure 3.3.5	Survey Question 5	42
Figure 3.3.6	Survey Question 6	42
Figure 3.3.7	Survey Question 7	43
Figure 3.3.8	Survey Question 8	43
Figure 3.3.9	Survey Question 9	43
Figure 4.1.1	Flowchart of proposed CLP	45
Figure 4.2.1	System Components Specifications Diagram	46
Figure 5.3.1	Check Node.js version	50
Figure 5.3.2	Create Node.js directory	50
Figure 5.3.3	Initialize new directory	51
Figure 5.3.4	Run Node.js Server	51
Figure 5.3.5	Create .sol file	52
Figure 5.3.6	Create .env file	52
Figure 5.3.7	Update hardhat.config.js	52
Figure 5.3.8	Write Deploy Script	53

Figure 5.3.9	Deployed Token Transaction Page on Etherscan Blockchain Explorer	53
Figure 5.4.1	Homepage	54
Figure 5.4.2	MetaMask Web Extension Popout	54
Figure 5.4.3	Navigation Bar After Logged In	55
Figure 5.4.4	Footer	55
Figure 5.4.5	Product List Page	55
Figure 5.4.6	Product Page	56
Figure 5.4.7	Product Description	56
Figure 5.4.8	Modal of Deploying Purchase Escrow Contract	57
Figure 5.4.9	MetaMask Web Extension Popout for Deploying Purchase Escrow Contract	57
Figure 5.4.10	Modal of Deploying Purchase Escrow Contract	58
Figure 5.4.11	Modal of Make Payment for Purchase	58
Figure 5.4.12	MetaMask Web Extension Popout for Making Payment for the Purchase	59
Figure 5.4.13	Modal of Making Payment for the Purchase	59
Figure 5.4.14	Purchase Transaction Completed	60
Figure 5.4.15	Modal of Selecting Redeem Loyalty Reward with Loyalty Points or NFTs	60
Figure 5.4.16	Modal of Deploy Loyalty Point Reward Escrow Contract	61
Figure 5.4.17	MetaMask Web Extension Popout for Deploying Loyalty Reward Escrow Contract	61
Figure 5.4.18	Modal of Deploying Loyalty Reward Escrow Contract	62
Figure 5.4.19	Modal of Deposit Loyalty Point for Loyalty Point Reward	62
Figure 5.4.20	MetaMask Web Extension Popout for Depositing Loyalty Point for the Loyalty Point Reward	62
Figure 5.4.21	Modal of Depositing Loyalty Point for the Loyalty Point Reward	63
Figure 5.4.22	Redeem Loyalty Point Reward Transaction Completed	63
Figure 5.4.23	Modal of Deploying NFT Reward Escrow Contract	63

Figure 5.4.24	MetaMask Web Extension Popout for Deploying NFT Reward Escrow Contract	64
Figure 5.4.25	Modal of Deploying NFT Reward Escrow Contract	64
Figure 5.4.26	Modal of Deposit NFTs for NFT Reward	65
Figure 5.4.27	MetaMask Web Extension Popout for Depositing NFTs for the NFT Reward Escrow Contract	65
Figure 5.4.28	Redeem NFT Reward Transaction Completed	66
Figure 5.4.29	Transaction History Page	66
Figure 5.4.30	MetaMask Web Extension Popout for Confirming the Order is Received	67
Figure 5.4.31	Confirming Delivery Transaction Completed	67
Figure 5.4.32	Transaction History Page After Confirming Delivery	68
Figure 5.4.33	MetaMask Web Extension Popout for Claiming Loyalty Point	68
Figure 5.4.34	Claiming Point Transaction Completed	69
Figure 5.4.35	Transaction History Page After Claiming Point	69
Figure 5.4.36	Admin Login Page	70
Figure 5.4.37	Admin Configuration Page	70
Figure 5.4.38	Upload Product Page	71
Figure 5.4.39	Modal of Add Inventory	71
Figure 5.4.40	Inventory Data Added into Inventory Table	72
Figure 5.4.41	Product successfully upload into Database	72
Figure 5.4.42	Product Successfully Uploaded into Database	73
Figure 5.4.43	Carousel Products Updated Successfully	73
Figure 5.5.1	Gantt Chart for FYP 2	74
Figure 6.1.1	After Login using MetaMask	75
Figure 6.1.2	Alert Dialog of Switching Network	76
Figure 6.1.3	Deployment of Contract Successful	76
Figure 6.1.4	Insufficient Balance	76
Figure 6.1.5	Payment Transferred to Contract	77

Figure 6.1.6	Balance of Contract	78
Figure 6.1.7	Modal of Successful Payment	78
Figure 6.1.8	Product in Transaction History Page After Payment Made	78
Figure 6.1.9	Payment Return Transaction Page on Etherscan Blockchain Explorer	79
Figure 6.1.10	Product in Transaction History Page After Confirming Order Received	80
Figure 6.1.11	Releasing Payment to Seller Transaction Page on Etherscan Blockchain Explorer	81
Figure 6.1.12	Claiming Point Transaction Page on Etherscan Blockchain Explorer	82
Figure 6.1.13	Product in Transaction History Page After Claiming Point	82

LIST OF TABLES

Table Number	Title	Page
Table 2.1.16.1	Summary of the Technologies Review	19
Table 2.3.1	Comparison between Proposed Project and traditional apparel CLP	25
Table 3.2.2.2.1	Use Case Description of Login using MetaMask	29
Table 3.2.2.2.2	Use Case Description of Purchase Products using Cryptocurrency	29
Table 3.2.2.2.3	Use Case Description of Redeem Products by spending Loyalty Point or Burning NFT	30
Table 3.2.2.2.4	Use Case Description of View Product Information	30
Table 3.2.2.2.5	Use Case Description of View Purchasing History	31
Table 3.2.2.2.6	Use Case Description of View Frequently Asked Questions (FAQ)	31
Table 3.2.2.2.7	Use Case Description of Login Admin Account	31
Table 3.2.2.2.8	Use Case Description of Configure Website	32
Table 5.1.1	Specifications of Laptop	49
Table 5.2.1.1	Hardware Requirements and Platforms of Visual Studio Code	49
Table 6.1.1	Unit Testing 1	75
Table 6.1.2	Unit Testing 2	75
Table 6.1.3	Unit Testing 3	77
Table 6.1.4	Unit Testing 4	79
Table 6.1.5	Unit Testing 5	80
Table 6.1.6	Unit Testing 6	81
Table 6.1.7	Unit Testing 7	83

Table 6.1.8	Unit Testing 8	84
Table 6.1.9	Unit Testing 9	85
Table 6.1.10	Unit Testing 10	86
Table 6.1.11	Unit Testing 11	86
Table 6.1.12	Unit Testing 12	86
Table 6.1.13	Unit Testing 13	86
Table 6.1.14	Unit Testing 14	87
Table 6.1.15	Unit Testing 15	87

LIST OF ABBREVIATIONS

CLP	Customer Loyalty Program
NFT	Non-fungible Token
PoW	Proof of Work
PoS	Proof of Stake
dApps	Decentralized Applications
API	Application Programming Interface
HTML	HyperText Markup Language
CSS	Cascading Style Sheets

CHAPTER 1: Introduction

1.1 Problem Statement and Motivation

Customer loyalty is crucial in the competitive world of the apparel industry. With ever-changing trends and fierce competition, building strong relationships with customers is the key to long-term success. A well-designed apparel customer loyalty program can help businesses attract and retain loyal customers, boost retention rates, and enhance the overall customer experience. However, there are some problems with the traditional CLP. One is privacy and security measures issues. Customers' data are held by the company centralized and any actions on the data are not controlled by the customers whether the company will deal with the data unethically or not. Also, the payment is directly transferred to the company's bank account, which may cause fraud cases to happen. Besides, some research stated that a portion of the CLP users have left the program due to the loyalty points usage is not flexible enough which didn't stimulate the users to spend within the business. Also, sustainability in the apparel industry is a concern for CLP users nowadays, they prefer to purchase apparel that is made up of sustainable materials and ethical sourcing, but the industry does not disclose this information to the consumers.

Lack of effective data privacy and security measures on customer-sensitive information

Privacy concern is one the main obstacles for customers while using or deciding whether to use the loyalty program or not because those data are under centralized control by the business, and customers have no idea how the business with deal with their data, whether they will keep it securely or trade it with others and how good is the security infrastructure such as firewall they have to keep customers' data safely. The malicious criminal will research the companies and learn the vulnerabilities of their system, eventually, they dive into the network and search for the data they want. [1] says that most data breaches are caused by stolen or weak credentials. The customer will be the biggest victim of data breaches when the leaked data is customer data because it can cause many problems such as financial loss and identity theft. [2] stated that Malaysia stands in 11th place among the countries with the highest breach

of personal user data for the second quarter of 2022. The University of Malaya (UM) cyber law expert Professor Dr Abu Bakar Munir said that from April until June in the year 2022, more than 665,200 Malaysian users had been hacked, and since 2004, 44.2 million hacked accounts reported during this period. The main cause of this alarming number of data leakage is the organizational system is inadequate and does not meet the desired standards. According to [3], Maybank, the largest bank in Malaysia encountered a data leak that involved 13 million bank account holders. The data leaks out to an online database marketplace.

Lack of payment security measures

sing is no intermediary overseeing the transactions unlike marketplaces such as Shopee, Amazon and Alibaba which have use escrow method for financial arrangement. According to the article [5], in the year 2021, Malaysians have been scammed for RM58 million to online shopping. [6] stated that in the year 2022, the Commercial Crime Investigation Department (JSJK) of the Royal Malaysian Police (PDRM) recorded 9,258 online scam sales cases, affecting individuals ranging from 15 to 61 years old and older. This payment security problem will cause the trust between buyer and seller broken and lead to a decline in customer loyalty.

Lack of flexibility in using loyalty points

When customers are not interested in exchanging rewards with earned loyalty points due to various kinds of factors, as a result, they will lose interest in using the *CLP*. According to [7], lack of valuable rewards, rewards or points earning speed is not commensurate with their habits, and fewer benefits are some reasons why customers leave a loyalty program. In summary, inelasticity in the usage of loyalty points is one of the main causes of why customers leave CLP. They didn't receive any incentive to spend in the business because the points they earned were valueless to them. As mentioned in [8], Antavo's Global Customer Loyalty Report 2023 found that only 48.6% of the loyalty points earned are redeemed by the members, others never be used. One of the reasons is the loyalty points are set with an expiry date, when the date is arrived those loyalty points will be erased from the member's account, and this leads to a bad experience for the member.

Lack of sustainability in the apparel industry CLP

During the apparel sector's shock and uncertainty caused by the COVID-19 crisis, there is a positive aspect for the environment. A survey reveals an overwhelming 88% of the respondents express the belief that greater emphasis should be placed on reducing pollution [9]. It means that consumers want apparel company to maintain their commitment to social and environmental responsibilities amid the crisis. Another survey from [10] stated that 67% of the responders consider the use of sustainable materials as their purchasing factor. These surveys indicated that consumers nowadays emphasise going green and ethical sourcing, which means that they will prioritize spending in the companies that make information such as the material used, manufacturing process, and labour conditions transparently and publicly to them because they can make better purchasing decisions. However, [11] shows that the 250 biggest brands in the world only obtained an average of 24% in the latest transparency index in the year 2022. A customer loyalty program is a strategy that retains customers and fosters brand loyalty and encourages continued purchases, but the problem is, how can a company retain customers if they don't want to spend?

1.2 Research Objectives

To resolve apparel CLP users' data privacy and security issues

The security problem that possibly happens in the traditional CLP is hackers using various techniques to gain unauthorized access to centralized systems or networks of a company that stores data such as customer-sensitive information. However, by implementing Blockchain into CLP, a decentralized technology where data is distributed across multiple nodes in the network, it reduces the risk of a single point of failure or data breach. Blockchain allows users to maintain their privacy by using pseudonyms or hashed addresses instead of revealing their real-world identities. Furthermore, it also incorporates advanced encryption techniques to secure user data. Transactions and data stored on the blockchain are encrypted, making it difficult for unauthorized individuals to access or decipher the information. Therefore, data privacy and security aspects are no longer depending on the company, but on Blockchain technology.

To enhance the payment security measures by intervention of third-party

The payment method from the buyer directly to the seller has caused many problems in society, of course, Malaysians do not survive from it either. People with bad intentions will take advantage of the trust given by the buyer and defraud them. To enhance the payment security, a third party, referred to as an escrow holder, will hold the funds, assets, or documents on behalf of two parties involved in a transaction. The holder will only release the funds, assets, or documents to the seller when the buyer receives what they paid for. However, it is slightly different in Blockchain-based escrow holders, the escrow holder is a contract address, which has no human intervention, where the buyer will transfer the funds to the contract address, and it will only release the funds to the seller by calling the smart contract method. The escrow holder's role is crucial in ensuring a fair and smooth transaction process, it ensures buyer will not lose their money when they do not receive what they paid for.

To provide another form of obtaining and spending loyalty points

A portion of the CLP users felt that the usage of loyalty points was inelastic due to various factors. To improve this issue, this project will use crypto tokens to replace the traditional platform-based tokens because they can be stored inside the blockchain wallet permanently, which guarantees do not have any expiry date. Also, it has better expandability compared to traditional loyalty points. For example, the apparel company can cooperate with other companies who also applied Blockchain-based CLP by allowing both side customers to spend the loyalty points in one another CLP. Besides, users will be rewarded an NFT that is related to the apparel that they have purchased, and there will be an NFT collection system where users can redeem loyalty rewards such as accessories products when they have successfully collected a certain set of NFTs. This brings in a new model of CLP which can increase the flexibility and expandability of loyalty points.

To increase the comprehensive transparency of the apparel lifecycle

As consumers are emphasizing going green and ethical sourcing, they prefer to purchase apparel that is made up of sustainable materials and ethical labour conditions, but most apparel companies do not disclose this information especially labor conditions to the consumers. To utilize the transparency and immutable record-keeping feature of Blockchain, users can view the entire supply chain of certain apparel products from raw material sourcing to manufacturing, distribution, and retail, blockchain creates an auditable and transparent trail of information by scanning a QR from the product display page. This aids consumers in identifying inefficiencies, unethical practices, and environmental impacts so that they can make more sustainable choices. Overall, this feature also helps to build brand loyalty because information transparency can enhance the trust of customers in the business.

1.3 Project Scope and Direction

The purpose of this project is to solve the problem encountered in the traditional apparel CLP. The outcome will be a website-based apparel CLP that is implemented with Blockchain technology. This CLP uses a Blockchain wallet, MetaMask to log into the account. This ensures that user information is stored decentralized, which has a much lower chance of getting breached by malicious criminals. Besides, a Blockchain-based escrow service will be integrated into the payment process to ensure a fair and smooth transaction process. In addition, crypto tokens will used to replace traditional platform-based tokens, so they can have further expandability such as cooperation with other businesses. Also, an NFT will be rewarded when the user purchases any apparel product, which can used to redeem exclusive loyalty rewards such as accessories products. Furthermore, users can check the information and product lifecycle of an apparel product such as materials and labor conditions on the product page. The involved users in this project are CLP users and sellers.

1.4 Contributions

This proposed project contributes to all apparel CLP users and the businesses that adopt the proposed CLP. With the help of Blockchain, the proposed project can eliminate the concern of customers' data being breached by malicious criminals. CLP users have more control over their data because their data is decentralized and stored in a distributed network, but not completely controlled by the business. Besides, CLP users will have more trust in the business due to the escrow holder ensures that users will only pay the seller when they successfully receive the product they paid for. It also benefits the business because customers will be more willing to spend on them. Furthermore, the proposed project provides further expandability on the loyalty points, the business can cooperate with other business loyalty programs that also adopted Blockchain-based loyalty programs because the loyalty point token is stored inside the CLP user's Blockchain wallet. The proposed CLP also introduces an NFT collection system that contains gamification elements which can retain customers and enhance customer loyalty and engagement. In addition, by enhancing the transparency of the apparel products in the business, CLP users will be more willing to spend than before because it will make customers trust the company more, which is a win-win situation.

1.5 Project Background

With the limited population in the world or within the apparel, a business would not only aim for new customers but also existing customers. Assume that the business has attracted all the people within the business region, after that, they will run out of business in a moment. Therefore, to have a sustainable business, the business should attract new customers, meanwhile, retain existing customers. By retaining existing customers, a business can build amazing relationships with their customers so that they will come back, again and again, to purchase products or use the services of the business [12]. To achieve the retention of customers, a Customer Loyalty Program can be implemented into the business.

CLP is used as a marketing strategy related to maintaining a long-term relationship with customers to increase the revenue of the organization and predict future

improvement activities [13]. This program can effectively market the products to customers based on their needs because it can be customized readily. This customizable marketing strategy encourages customers to use the program frequently so that it reaches the purpose of retaining existing customers. According to [14], Annex Cloud's clients that have implemented CLP have increased their overall revenue by 5-10% and loyalty program members purchase 5-20% more frequently than non-members, which is statistically effective. Starbucks Coffeehouses Company is one of the examples that has used spend-based CLP, which is called Starbucks Rewards. [15] stated that Starbucks Rewards members drove 53% of United States company-operated revenue in the third quarter of the year 2022. Although it indeed increased the revenue of the businesses that adopted the CLP, it faces challenges such as **data privacy and security issues, lack of flexibility in using loyalty points, and lack of sustainability on the CLP.** To address these issues Blockchain technology can be fused with traditional CLP.

Blockchain technology offers a decentralized and transparent platform that can reshape loyalty programs in various industries, including apparel. Its unique features, such as immutability, transparency, and smart contracts, can address the limitations of traditional loyalty programs and deliver enhanced value to both businesses and customers. By implementing a blockchain-based loyalty program, apparel brands can create a seamless and interoperable system where customers can accumulate and redeem rewards across different participating brands in the future. The use of smart contracts enables the automated execution of loyalty program rules and simplifies business processes.

1.6 Report Organization

This report is organized into 7 chapters: Chapter 1 Introduction, Chapter 2 Literature Review, Chapter 3 System Methodology/Approach, Chapter 4 System Design, Chapter 5 System Implementation, Chapter 6 System Evaluation and Discussion, and Chapter 7: Conclusion and Recommendation. The first chapter introduces this project which includes the problem statement and motivation, project objectives, project scope, project contribution, project background, and report organization. The second chapter is literature review carried out on several existing apparel customer loyalty program in Malaysia to evaluate the strengths and weaknesses of each product. The third chapter shows the overall system design of this project. The fourth chapter is regarding the details of how to implement the design of the system. The fifth chapter will discuss how the system is implemented in the development environment. Then, the sixth chapter will discuss the evaluation of the system. Lastly, the final chapter gives a brief conclusion of the overall report and recommendations for future work.

CHAPTER 2: Literature Reviews

2.1 Review of technology used

2.1.1 Blockchain

In short, Blockchain technology is a digital database or ledger that is distributed among the nodes of a peer-to-peer computer network [16]. This technology was invented by Satoshi Nakamoto in 2008. It has some exciting features such as immutable, decentralized, secure, transparent, consensus and unanimous [16]. The most famous implementation of Blockchain in recent years is the cryptocurrency system which can maintain a secure and decentralized record of transactions such as Bitcoin (BTC), Ether (ETH), and Tether (USDT). Besides cryptocurrencies, there are also new creations such as decentralized finance (DeFi) applications, non-fungible tokens (NFT), and smart contracts.

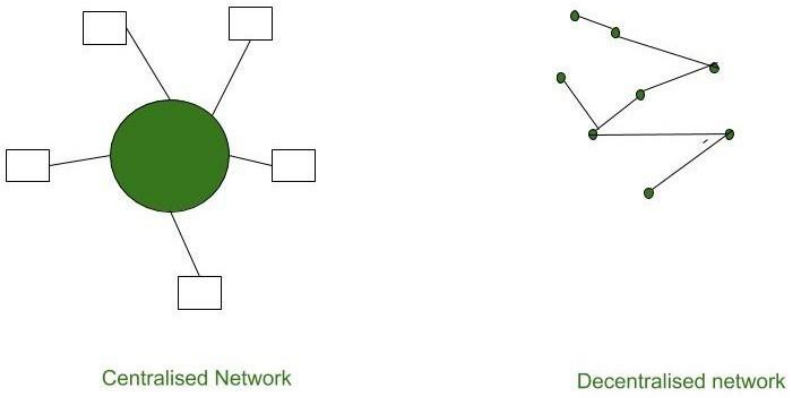


Figure 2.1.1 The difference between centralized and decentralized networks

The transaction process in a Blockchain can be partitioned into 6 steps [17]. The first step is facilitating a new transaction into the Blockchain network where all the transaction information is needed to transmit with encryption doubly using public and private keys. Then, the next step is to verify the transaction by transferring it to the distributor peer-to-peer computer network across the world. All the nodes, or every computer in the network will validate the transaction such as checking whether enough balance to carry out the transaction. Next, if the transaction is verified, then it will be declared a legitimate transaction and it will be added to the mempool, which is used to store information and pending transactions, and multiple mempools will form

a block. In the fourth step, nodes will try to add the formed block into the network, but it will form an issue if every node is allowed to add a block into the network without any restrictions. Consensus mechanisms such as Proof of Work (PoW) and Proof of Stake (PoS) solve this issue, by the end of the algorithm, a hash code will be created for that pending block. If the block successfully gets the hash code, then it is authenticated, and it will be added to the Blockchain network. After the block is added to the network, the transaction is completed and permanently stored in the Blockchain, and anyone can fetch the details of the transaction.

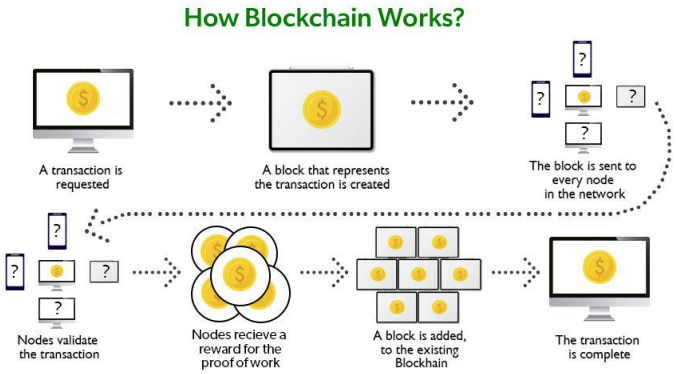


Figure 2.1.2 How Blockchain Works

Although Blockchain is well-known for its security due to its decentralization, there are still some vulnerabilities in it. One of them is 51% attacks, this attack happens when the threat actors gain control by owning more than half of the blockchain's computing power [18]. This allows them to corrupt the integrity of the Blockchain transaction such as by adding false transactions into the Blockchain network. The factor that prevents 51% attack is its cost. For example, the most advanced application-specific integrated circuit (ASIC) miner is Bitmain S19 XP Hydro which costs around RM 40,000, and to equal the hash rate of the mining pool, the attacker needs to own more than 941,634 ASIC which total cost around RM 35 billion to attack the Bitcoin network [19].

2.1.2 Smart Contract and Solidity

Smart Contract is a computer program that runs on Blockchain such as Ethereum, and it is designed to execute predefined actions automatically when certain conditions are met [20]. It operates as a self-executing contract that enforces rules and terms encoded inside its code without any intermediary's involvement or time delay. By using Smart Contracts, transactions are traceable, transparent, and irreversible. There are three types of blockchains for smart contracts which are categorized into public, private and hybrid. Public means that the network is open to the public to join, private is restricted to those authorized entity members, and hybrid is the combination of public and private. The examples of Blockchains that support smart contract are Ethereum, Hyperledger Fabric, and EOS [21].

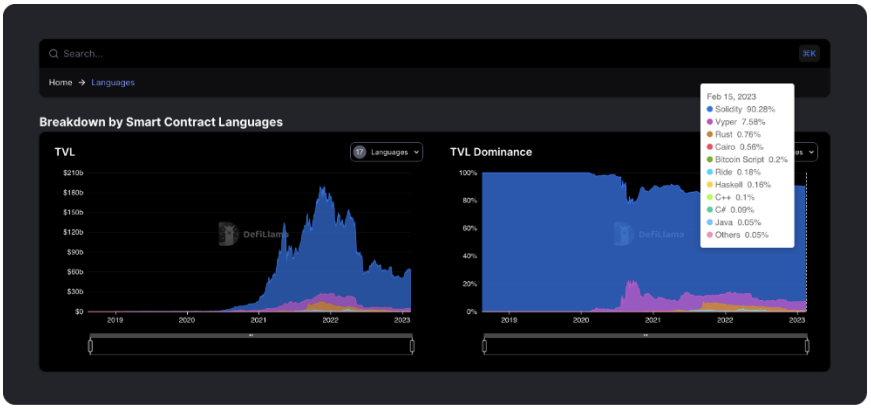


Figure 2.1.3 Breakdown by Smart Contract Languages

To write a smart contract, a programming language such as Solidity, Vyper, or Rust is needed. Among that blockchain programming language, Solidity stands as the most widely adopted programming language for the Ethereum Virtual Machine (EVM), finding extensive usage in various blockchains compatible with the EVM [22]. Solidity is a high-level, statically typed object-oriented programming language designed for developing and implementing smart contracts on the Ethereum blockchain [23]. It combines elements of JavaScript and Python, making it accessible to a broad range of developers. Solidity allows developers to define the rules and logic of dApps by creating self-executing contracts with predefined conditions and functions. These contracts are deployed on the Ethereum network, enabling trustless and automated execution of agreements, from financial transactions to complex governance systems [24]. Solidity's versatility, security features, and compatibility

with Ethereum's ecosystem have established it as the predominant language for building dApps, powering the rapidly growing world of blockchain-based solutions.

2.1.3 Remix IDE

Remix IDE is a powerful online development environment tailored for Ethereum smart contract development, offering a feature-rich editor for writing Solidity code with syntax highlighting and error checking, a built-in compiler for generating EVM bytecode, a debugger for tracing contract execution and inspecting variables, deployment tools for deploying contracts to various Ethereum networks, static analysis capabilities for identifying security vulnerabilities and gas optimization opportunities, support for plugins and extensions to extend functionality, and seamless integration with Ethereum networks for testing and deployment [25].

2.1.4 Ethereum Sepolia Testnet

Testnet is a separate blockchain network designed for testing and experimentation purposes. It is distinct from the main blockchain network, which is also called mainnet, and it is used primarily by developers, researchers, and users who want to test applications, smart contracts, and other blockchain-related functionalities without using real cryptocurrency. It is a critical component of blockchain development, offering a safe and risk-free environment for experimenting, testing, and refining blockchain-based applications and features before they are deployed on the production mainnet [26].

Sepolia, launched as a proof-of-authority testnet in October 2021 by Ethereum core developers, transitioned to a proof-of-stake consensus mechanism alongside the Goerli testnet after Ropsten's Terminal Total Difficulty (TTD) exceeded 50000000000000000. Serving as a crucial testing ground for Ethereum developers, Sepolia replicates mainnet conditions while operating on a separate ledger, allowing developers to test applications and smart contracts without risking real funds. With its shorter block times, Sepolia provides rapid transaction confirmations and valuable feedback for developers, distinguishing it from other testnets like Goerli. Notably,

Sepolia boasts an uncapped supply of testnet tokens, mitigating concerns of token scarcity often encountered on other testnets [27].

2.1.5 Google Firebase

Firebase is an all-sided mobile and web application development and backend-as-a-service platform. It offers plenty of tools and services that able to helps application developers on building and improving their applications within a short time. The features that provided by Firebase are real-time database, cloud hosting, authentication, cloud functions, analytics, and a lot more. It is a popular choice for application developers looking to streamline the development and deployment process because it's easy to use and can be integrated with other Google services seamlessly, [28]. The examples of popular application that are using Google Firebase are Alibaba, Duolingo, and The New York Times.

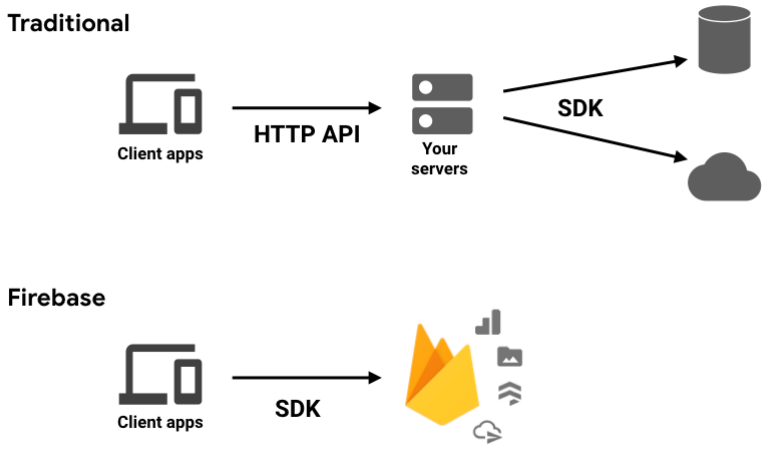


Figure 2.1.4 Traditional App Development vs. Firebase App Development

2.1.6 MetaMask

MetaMask is a popular free cryptocurrency wallet that accessible on both web and mobile platforms. It that enables users to interact with the Ethereum blockchain. It functions as both a digital wallet for securely storing Ethereum and other compatible cryptocurrencies and a gateway to dApps on the Ethereum network. It serves three

core purposes which are storage, swaps, and dApp access. Users can manage their cryptocurrency assets, send and receive transactions, and access dApps such as games and financial services within users' browsers. It acts as a bridge between traditional web browsers and the decentralized web, providing a user-friendly interface for blockchain interactions [29].

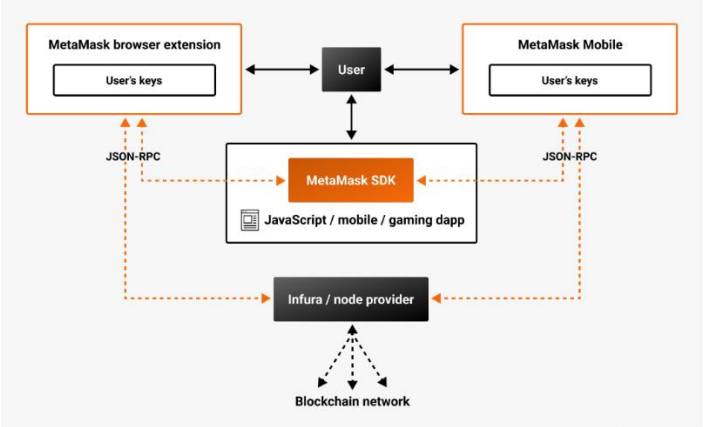


Figure 2.1.5 MetaMask Architecture

2.1.7 Pinata

Pinata is a popular and user-friendly content-addressable storage (CAS) platform built on top of the InterPlanetary File System (IPFS). It allows users to store and manage digital assets, such as images, videos, and other files, in a decentralized and secure manner, which provides users the ability to host their NFT content on the decentralized web3. Also, Pinata provides simple tools and APIs for developers to interact with IPFS easily such as integrating decentralized file storage with other applications or projects. [30].

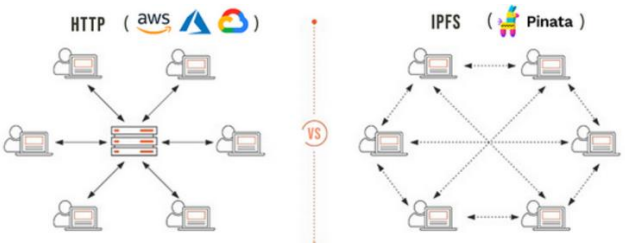


Figure 2.1.6 Difference between HTTP and IPFS

2.1.8 JavaScript, HTML and CSS

JavaScript is a programming language primarily used for web development, enabling dynamic and interactive content on websites. It runs on the client side, meaning it executes within the user's web browser, allowing for real-time manipulation of web page elements, handling user interactions, and performing calculations. HTML (Hypertext Markup Language) is the standard markup language used to create the structure of web pages. It provides the skeleton of a webpage, defining the layout and organization of content using elements like , <p>, <header>, and <footer>. CSS (Cascading Style Sheets) is a style sheet language that complements HTML by controlling the presentation and appearance of web pages. It allows developers to define styles such as colours, fonts, spacing, and layout, providing a visually appealing and consistent design across multiple web pages. Together, JavaScript, HTML, and CSS form the foundation of modern web development, enabling the creation of dynamic, responsive, and visually appealing websites and web applications [31].

2.1.9 Node.js

Node.js is an open-source server-side runtime environment that enables developer execute JavaScript code with the Chrome V8 JavaScript engine on the server.

It is popular for the event-driven and non-blocking I/O architecture, which allows it to handle multiple connections efficiently. Moreover, Node.js is commonly used to develop scalable and high-performance web applications, real-time applications, and APIs. Besides, Node.js can run on various platforms such as Windows, Linux, Unix, Mac OS X, etc. Its extensive ecosystem of packages and libraries, accessible through npm, further enhances its capabilities and developer productivity [32].

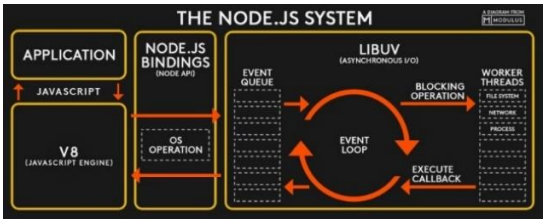


Figure 2.1.7 Node.js System Architecture

2.1.10 Express.js

Express.js is a popular and light weighted web application framework for Node.js. It is designed for building web applications and APIs. It provides a set of powerful features for application development, which make it a good option for developers to use for their development. For example, the routing system allows developers to define routes and their associated handlers for different HTTP methods such as GET and POST. Also, due to it is light weighted and efficient, it can handle many concurrent connections without sacrificing performance [33].

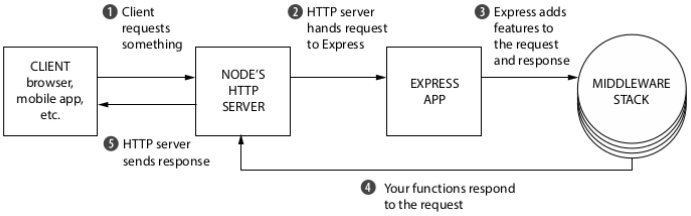


Figure 2.1.8 Expree.js process

2.1.11 Pug.js

Pug.js is a template engine for Node.js and browsers with high rendering performance. It is used to generate dynamic HTML content on the server side. Pug uses intuitive syntax that makes it easier for developer to write and maintain templates for web applications. It also simplifies HTML generation with its simple syntax, enhancing productivity and code readability. It facilitates the creation of reusable HTML components and the seamless rendering of data sourced from databases or APIs, making web development more efficient [34].

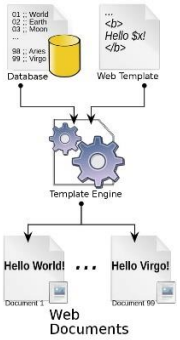


Figure 2.1.9 Template Engine

2.1.12 Web3.js

Web3.js is a JavaScript library that allows developers to interact with the Ethereum blockchain and decentralized applications (DApps) from within web applications. It provides a set of APIs that enable communication with Ethereum nodes, allowing developers to read data from the blockchain, send transactions, deploy smart contracts, and listen for events. Web3.js abstracts away the complexities of interacting directly with Ethereum nodes, providing a simplified and user-friendly interface for developers to build Ethereum-powered applications. It supports both browser-based and Node.js environments, making it versatile for use in various types of web applications. With Web3.js, developers can create decentralized applications that leverage the capabilities of the Ethereum blockchain to enable trustless transactions, decentralized finance (DeFi) protocols, non-fungible tokens (NFTs), and more [35].

2.1.13 Babelify

Babelify is a tool that integrates Babel with Browserify, a popular JavaScript bundler. Babel is a JavaScript compiler that allows developers to write code using the latest ECMAScript syntax (ES6/ES7/ESNext) and then transpile it into backward-compatible versions of JavaScript that can run in older browsers or environments that do not support the latest features. Browserify, on the other hand, is a module bundler that enables developers to use the require() function from Node.js in the browser.

Babelify combines the capabilities of Babel and Browserify, allowing developers to write modern JavaScript code with ES6+ syntax, use npm modules, and bundle everything together into a single file that is compatible with older browsers. It automatically transpiles the ES6+ code into ES5 code that is widely supported across different browsers, making it easier to develop web applications using modern JavaScript features while ensuring broad compatibility. This is particularly useful for developers who want to leverage the latest JavaScript language features without worrying about browser support issues [36].

2.1.14 Nodemon and Watchify

Nodemon and Watchify are both tools commonly used in web development, albeit serving different purposes. Nodemon is a utility for Node.js that monitors changes in your server-side JavaScript files and automatically restarts the server whenever a change is detected. This is incredibly useful during development, as it eliminates the need to manually stop and restart the server every time you make a code change. Nodemon essentially streamlines the development process by providing a seamless way to test and iterate on server-side code without interruption [37].

On the other hand, Watchify is a module bundler specifically designed for client-side JavaScript development. It operates similarly to Browserify but with an added feature: it watches for changes in your JavaScript files and automatically rebuilds the bundle when modifications occur. This means that as you make changes to your client-side code, Watchify detects those changes and efficiently updates the bundled JavaScript file, significantly speeding up the development workflow. With Watchify, developers can focus on writing code without worrying about manually rebuilding their bundles every time they make a change [38].

2.1.15 Alchemy

Alchemy is a blockchain infrastructure platform that provides developers with the tools and services for building and scaling dApps on different Blockchain networks. In addition, Alchemy acts as a provider of a communication channel between a developer and the Blockchain, which is called a node [39]. It also offers solutions for developers such as API services, developer tools, and analytics to simplify and speed up their blockchain development. Alchemy supports multiple blockchains, including Ethereum, and is known for its reliability, scalability, and user-friendly interface, making it a preferred choice for blockchain developers aiming to create robust and efficient dApps [40].

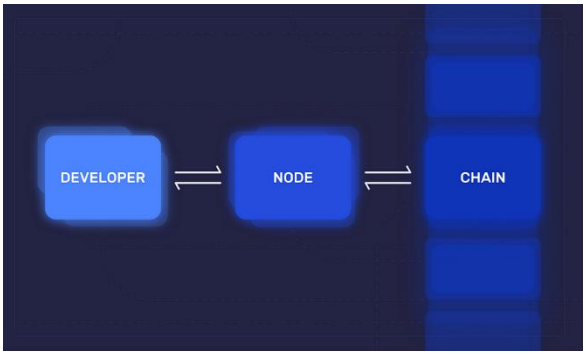


Figure 2.1.10 Communication channel between Developer and Blockchain

2.1.16 Summary of the Technologies Review

Type	Name	Description
Cryptocurrency Wallet	MetaMask	A crypto wallet that operates as a browser extension, allowing users to manage and interact with cryptocurrencies and dApps.
Ethereum Testnet	Ethereum Sepolia Testnet	A cross-client proof-of-authority testing network for Ethereum
Text Editor	Visual Studio Code	A streamlined code editor with support for development operations like debugging, task running, and version control
Front End Framework	HTML	A markup language used for creating and structuring the content of web pages.
	CSS	A style sheet language that defines the visual presentation of HTML or XML documents on the web.
IPFS Gateway	Pinata	A web3 development platform that offers the advantage of scalable storage through IPFS
Application development SDK	Firebase	A set of backend cloud computing services and application development platforms
Blockchain Developer Platform	Alchemy	A blockchain infrastructure platform that provides a suite of developer tools and services to simplify and accelerate blockchain development
Blockchain Explorer	Etherscan	A widely used blockchain explorer and analytics platform primarily focused on the Ethereum blockchain

Programming Language	Solidity	A high-level programming language specifically designed for writing smart contracts on blockchain platforms
	Javascript	A lightweight interpreted programming language used for developing the front-end and back-end part.
IDE	Remix	A web-based integrated development environment (IDE) for Ethereum smart contract development
Server environment	Node.js	An open-source, server-side runtime environment built on the Chrome V8 JavaScript engine
Node.js Framework	Express.js	A minimalist and flexible web application framework for Node.js
Template engine	Pug.js	A templating engine for JavaScript that simplifies the process of generating HTML markup.
Ethereum JavaScript API	Web3.js	A collection of libraries that allow developer to interact with a local or remote Ethereum node using HTTP, IPC or WebSocket
Transpiler	Babelify	A browserify transform that transpiles JavaScript code written using modern ECMAScript features into a backwards-compatible version for older browsers.
Development Tool	Nodemon	A utility that automatically restarts Node.js applications whenever changes are detected in the source code, facilitating a smoother development workflow.
	Watchify	A tool that efficiently monitors changes in browserify-based JavaScript projects and automatically recompiles them, enhancing development productivity by providing real-time updates during development.

Table 2.1.16.1 Summary of the Technologies Review

2.2 Review of the Existing Apparel Customer Loyalty Program in Malaysia

2.2.1 Customer Loyalty Program

Nowadays, major businesses have implemented *CLP* into their business models. For instance, Starbucks, FamilyMart, Grab Malaysia, FoodPanda, AirAsia, AEON, and a lot more [40]. One can imagine that the *CLP* indeed helped businesses to increase the loyalty of their customer, which have a positive correlation with profitability [41]. Although many businesses are implementing the same loyalty program concept, there is also some different modality of loyalty programs in the market such as Points-based, Tiered, Paid, Value-based, and more [42]. A good *CLP* can make customers more likely to stay with the brand, and it is supported by many factors such as value, convenience in engagement, simplicity, and more. In this review, I will review four existing apparel loyalty program systems, which are Whimsigirl, TNTCO, ANAABU, and Pestle & Mortar Clothing**.**

2.2.2 Whimsigirl

Whimsigirl is a fashion e-commerce startup based in Kuala Lumpur, Malaysia. The clothes collection that customers can find from Whimsigirl are many such as creative, corporate, minimalistic, girly, sporty, expectant mum, and nursing mum. They offer a customer loyalty program for their customers where customers can enjoy exclusive access to product launches, birthday gifts and shopping experiences from it. Its CLP members can earn points through various activities such as creating an account, following Whimsigirl's Instagram and Facebook account, referring friends, and making purchases, and members can receive 2500 points on their birthday. Members can turn the loyalty points into credits which can make a discount for their next purchase, where 1000 points are valued at RM 10 credits. To register as a CLP member, customers need to provide their name, email, and password. On this product display page, customers can find information such as specifications, good to know, care instructions, and measurements of the product. Also, the points do not expire and can be redeemed at any time. The payment methods provided by whimsigirl are iPay88 Malaysia and Grab [43].

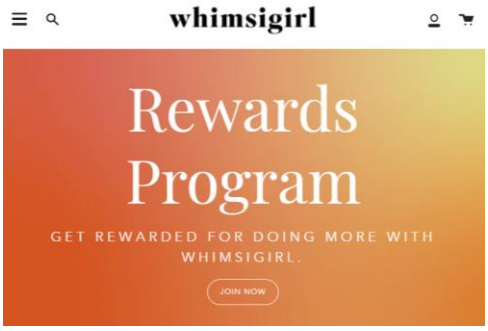


Figure 2.2.2.1 CLP page of Whimsigirl

2.2.3 TNTCO

TNTCO is a Malaysia local streetwear company that was founded in 2013. The membership program of TNTCO was introduced with their S.A.T Project in the year 2021 [44]. The categories of their products included tees, shorts, shirts, bottoms, outerwear, and accessories. Users can collect loyalty points by signing up for an account, making purchases, following the social media accounts if TNTCO, birthday gifts, and referring friends. During the 11th week of S.A.T Program, a special promotion has been rolled out as well where customers will receive an additional 916 points when they spend above RM 300, and 160 points when they spend below RM 300 [45]. The loyalty points can be used to redeem items such as laundry bags, key holders, Rubik's Cube, and a few more which are not for sale. Furthermore, the name, email, and password of the customer are needed to create a member account. The product details such as specifications, washing instructions, and measurements can be viewed on the product page. The payment methods provided by TNT.CO have iPay88 Malaysia and Atom PayLater [46].

Figure 2.2.3 CLP page of TNTCO

2.2.4 ANAABU

ANAABU is a Malaysian local apparel brand founded in 2010. Its design is intimate with minimal adornment and muted colors. The apparel products that can be found from ANAABU include tops, bottoms, dresses, outerwear, accessories, and hosiery. The CLP rolled out by ANAABU is called ANAABU Rewards where members can earn points through signing up, birthday gifts, placing orders, subscribing to newsletters, leaving reviews, following and sharing ANAABU's social media accounts, and referring friends. The points owned by users can be turned into a discount on the next purchase, where 1000 points can be exchanged for RM 10 offer. Inside the CLP, there's a tier program which classified into Bronze, Silver, and Gold. The higher the tier, the points multiplier more and the discount on every purchase increases. Users can create an account without manually keying in their name, email, and password they can sign up with their other accounts such as Google and Facebook. The details of the product included features, styling tips, measurements, and care instructions. The payment methods provided by ANAABU are iPay88 Malaysia, Grab, PayPal, Atome PayLater, ShopBack and Credit card [47].

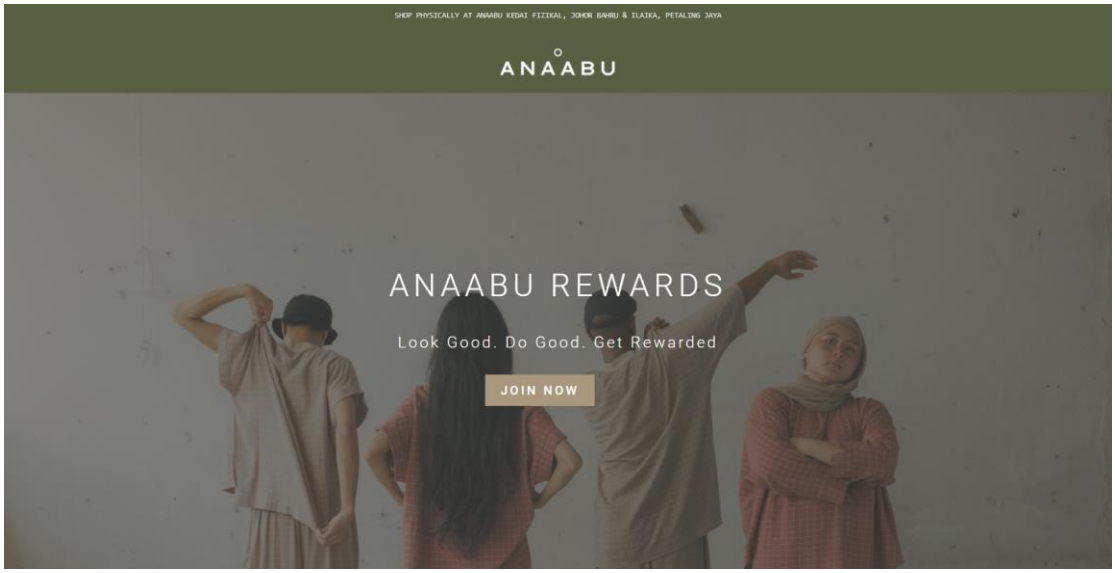


Figure 2.2.4 CLP page of ANAABU

2.2.5 Pestle & Mortar Clothing

Pestle & Mortar Clothing or PMC is a Malaysian streetwear brand based in Kuala Lumpur. They champion Southeast Asia's culture through their apparel products. The CLP of PMC is called “Homie Rewards” where members can gain points through spending online or in-store, signing up for an account, birthday gift, following PMC’s social media accounts, and referring friends to PMC. Users can spend their loyalty points to get discounts on their purchases with a minimum purchase of RM100 or free shipping with no minimum purchase. To register an account for PMC, the user’s name, email, and password is needed. From the product page, users can get the product information such as features. The payment methods provided by PMC are Paypal, Grab, ShopBack, Razer Merchant Services, and Atome PayLater [48].

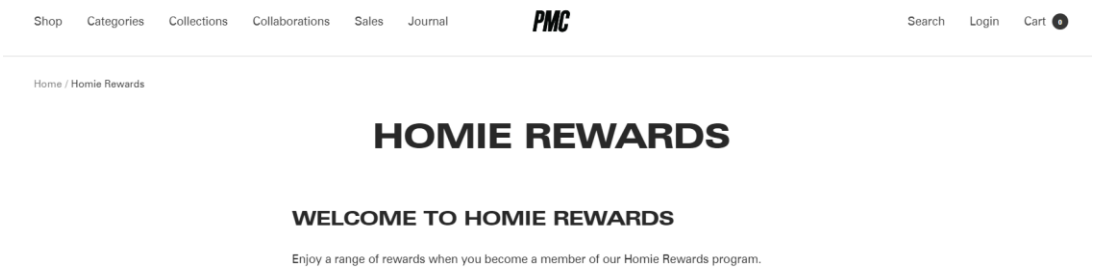


Figure 2.2.5 CLP page of Pestle & Mortar Clothing

2.3 Critical Remarks of previous work

	Whimsigirl	**TNTCO**	**ANAABU**	**Pestle & Mortar Clothing**	**Proposed Solution**
Login Method	**Email and password**	**Email and password**	**Email and password or other accounts**	**Email and password**	**Blockchain wallet**
Payment Method	**Directly to seller**	**Directly to seller**	**Directly to seller**	**Directly to seller**	**To escrow holder contract address**
View features of a product	✓	✓	✓	✓	✓
Redeem loyalty reward	✓	✓	✓	✓	✓
Redeem loyalty reward using NFT	✗	✗	✗	✗	✓
View product lifecycle information	✗	✗	✗	✗	✓
Transaction data store in Blockchain	✗	✗	✗	✗	✓
Use Blockchain to automate payment process	✗	✗	✗	✗	✓

Table 2.3.1 Comparison between Proposed Project and traditional apparel CLP

CHAPTER 3: System Methodology/Approach

3.1 Design Specifications

3.1.1 Methodology

For this proposed system, Test Driven Development (TDD) will be the most suitable software development methodology. TDD is often categorised as an Agile software development practice because it aligns with Agile principles such as iterative development and continuous testing. It is suitable for FYP because it is a solo project, we do not have any team members, this methodology forces me to define specific test cases before writing code, which helps me to gain a clear understanding of the requirements and expected behaviour of my proposed solution. TDD has three phases which are **Red**, **Green** and **Refactor**.

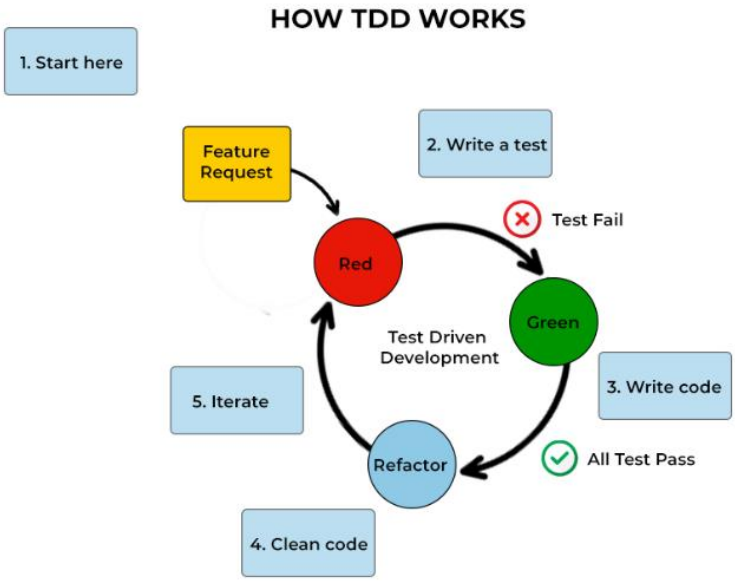


Figure 3.1.1.1 How TDD Works

In the first phase, the Red phase which is also the starting point of the cycle, a failing test is needed to be created in this phase to inform the implementation of a feature. This test represents the understanding of the requirements and acts as a specification for future code. The test will only pass when its expected outcomes are achieved. Followed by the second phase, the Green phase where the minimum amount of code necessary to make the failing test pass. The goal of this phase is to discover a solution

without the need to be concerned about optimizing the implementation. After this phase, it will be considered “in the green”, and the next phase will proceed with optimizing the code. Next is the Refactor phase, In this phase will work on improving the code so that the code can run more efficiently. After refactoring, rerun the tests to verify that everything is still working as expected. Lastly, the Red-Green-Refactor cycle is repeated for each new piece of functionality added or modified.

3.2 System Design Diagram

The involved system design diagrams have System Architecture Diagram, Flowchart, Use Case Diagram, and Activity Diagram.

3.2.1 System Architecture Diagram

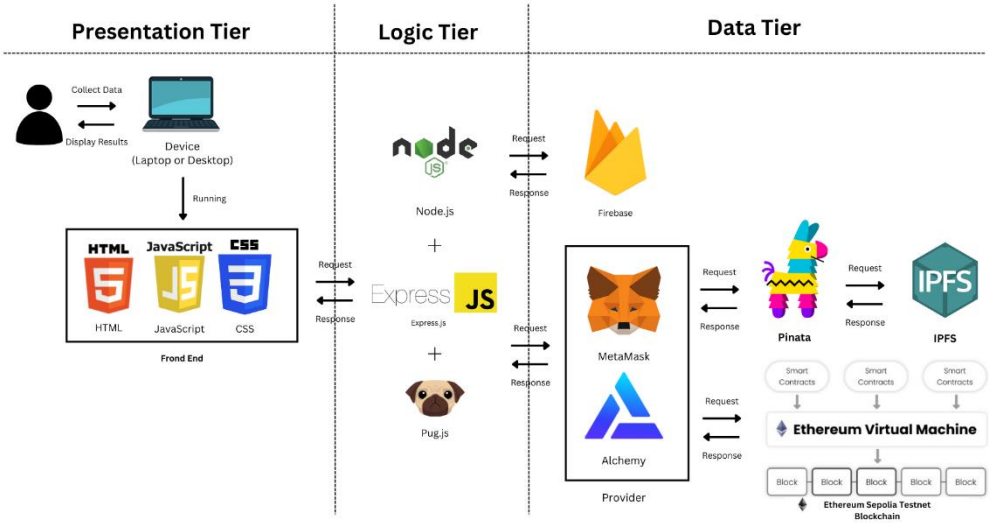


Figure 3.2.1.1 System Architecture Diagram of proposed CLP

The figure above shows three tiers in the system architecture including Presentation, Logic, and Data. In the first tier, the Presentation tier, users will interact with their devices such as laptops or desktops. The device will run the front end and pass the collected data from the user to the front end, which includes HTML, JavaScript, and CSS. The front end will make requests on the data collected to the next two tiers. The Logic tier including node.js and express.js will route and validate the data. After routing and validating the data, it will pass the data to the Data tier whether the user

wants to interact with Firebase or the Blockchain. If users intend to interact with the Blockchain, they need to make requests through providers such as MetaMask and Alchemy, then the provider will make a request to Pinata, which is the simple tools and APIs to interact with IPFS, or the Ethereum Sepolia Testnet based on the collected data from the user. Eventually, the Data tier will give responses to the Logic tier, when pug.js receives the response from the Data tier, it renders dynamic HTML content with data fetched or processed and gives responses to the presentation tier and displays on the user device.

3.2.2 Use Case Diagram and Description

3.2.2.1 Use Case Diagram

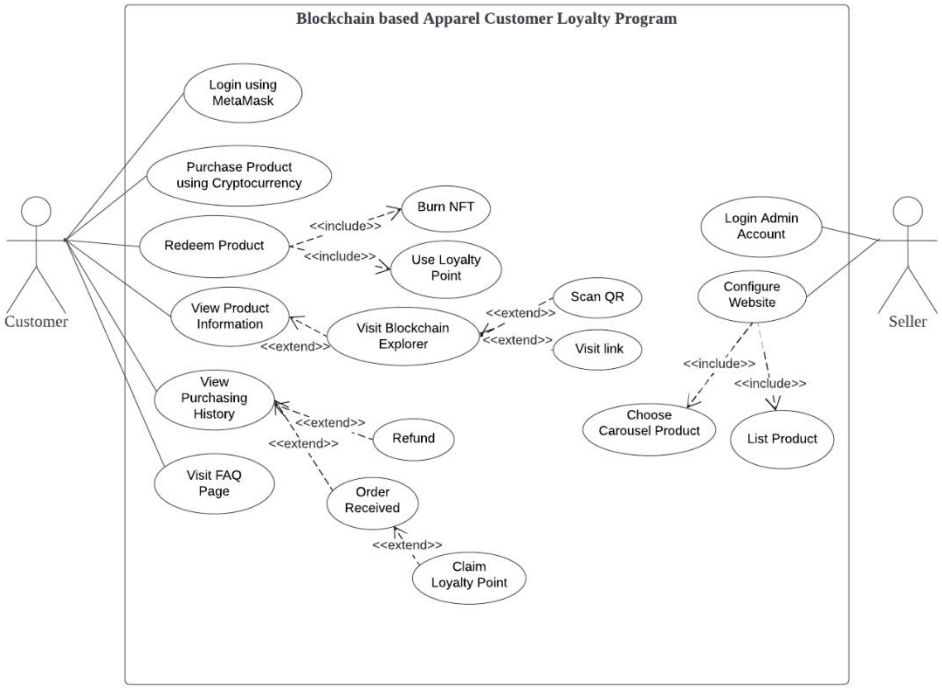


Figure 3.2.2.1.1 Use Case Diagram of proposed CLP

3.2.2.2 Use Case Description

Use Case Name	**Login using MetaMask**
Primary Actor	**Customer**
Trigger	When customer click on the connect button or enter homepage or product page
Basic Flow	1. When the use case is triggered, the MetaMask web extension will pop out. 2. Keying in password to the MetaMask web extension.
Alternate Flow	1. If customer not yet install MetaMask web application, they need to install it. 2. After installing MetaMask, they can choose to create new wallet or import existing wallet to the extension. 3. Then, they proceed to login using MetaMask.
Exception Flow	The entered password is not valid.

Table 3.2.2.2.1 Use Case Description of Login using MetaMask

Use Case Name	**Purchase Products using Cryptocurrency**
Primary Actor	**Customer**
Trigger	When customer click purchase button
Basic Flow	1. The customer deploys an escrow service contract. 2. The customer transfers cryptocurrency to the escrow contract.
Alternate Flow	1. If customer has not enough cryptocurrency to make payment, a prompt will pop out to remind customer.
Exception Flow	The customer does not have enough cryptocurrency to make the purchase.

Table 3.2.2.2.2 Use Case Description of Purchase Products using Cryptocurrency

Use Case Name	**Redeem Products by spending Loyalty Point or Burning NFT**
Primary Actor	**Customer**
Trigger	When customer click redeem button
Basic Flow	1. The customer deploys an escrow service contract. 2. The customer chooses whether redeem with loyalty point or burning NFT. 3. The customer transfers loyalty to the escrow contract.
Alternate Flow	• If customer has not enough loyalty point to redeem, a prompt will pop out to remind customer. • If customer does not collect full set NFT to redeem, a prompt will pop out to remind customer.
Exception Flow	• The customer does not have enough loyalty point to redeem. • The customer does not collect the full set NFT to redeem.

Table 3.2.2.2.3 Use Case Description of Redeem Products by spending Loyalty Point or Burning NFT

Use Case Name	**View Product Information**
Primary Actor	**Customer**
Trigger	When customer enter product page
Basic Flow	• The customer views the product information by reading the information from the product page.
Alternate Flow	• If customer choose to scan to the QR code, they will be directed to the blockchain explorer. • If customer choose to visit the link, they will be directed to the blockchain explorer.
Exception Flow	None

Table 3.2.2.2.4 Use Case Description of View Product Information

Use Case Name	**View Purchasing History**
Primary Actor	**Customer**
Trigger	When customer click “Purchase History” button
Basic Flow	• The customer refunds their purchased item. • The customer confirms the product has been received. • The customer claim loyalty point
Alternate Flow	None
Exception Flow	None

Table 3.2.2.2.5 Use Case Description of View Purchasing History

Use Case Name	**View Frequently Asked Questions (FAQ)**
Primary Actor	**Customer**
Trigger	When customer click “FAQ” link in footer section
Basic Flow	• The customer views the FAQ in the page they are directed to
Alternate Flow	None
Exception Flow	None

Table 3.2.2.2.6 Use Case Description of View Frequently Asked Questions (FAQ)

Use Case Name	**Login Admin Account**
Primary Actor	**Seller**
Trigger	When seller click “Admin” link in footer section
Basic Flow	• The seller login to the administrator page by keying in the admin username and password.
Alternate Flow	None
Exception Flow	The seller's username and password are not valid.

Table 3.2.2.2.7 Use Case Description of Login Admin Account

Use Case Name	**Configure Website**
Primary Actor	**Seller**
Trigger	When seller click buttons such as “Upload Product” inside the Admin page
Basic Flow	• The seller lists the product by key in information such as product picture, description, and price. • The seller chooses the products to display in the homepage’s carousel
Alternate Flow	None
Exception Flow	The seller does not enter all the required information.

Table 3.2.2.2.8 Use Case Description of Configure Website

3.2.3 Activity Diagram

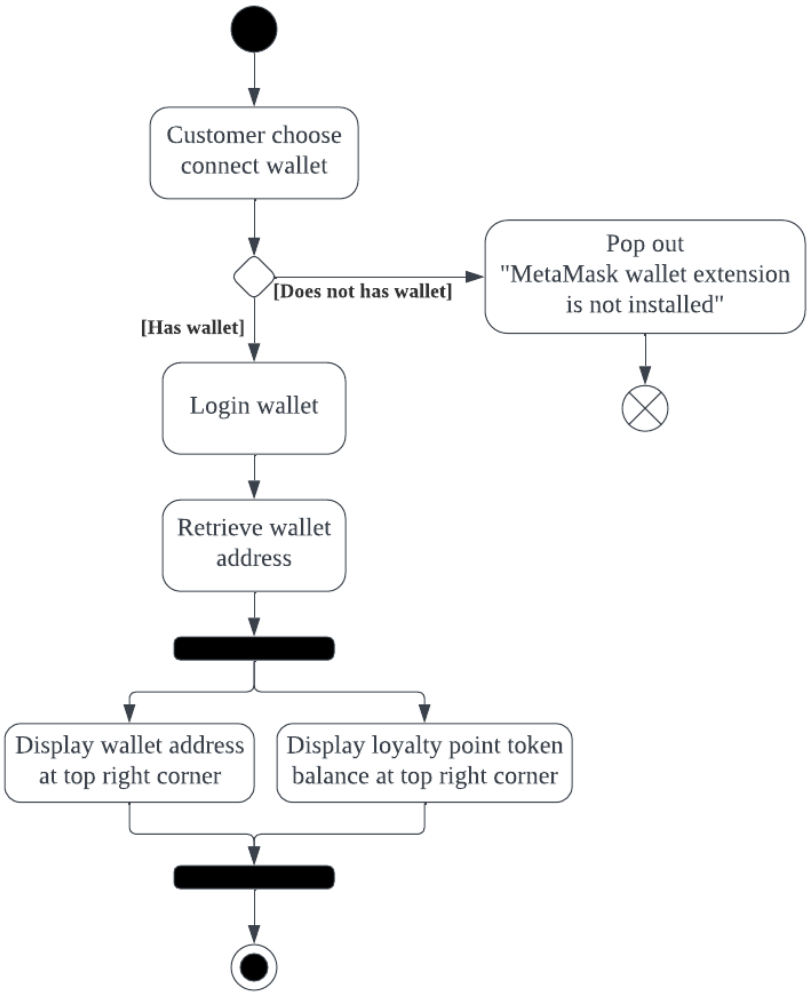


Figure 3.2.3.1 Activity Diagram of Customer Login Account

The figure above shows the process of a customer logging in to their account. When the customer chooses to connect their wallet, if the customer does have the wallet extension in the browser, the customer will be requested to login wallet, otherwise a pop-out shows “MetaMask wallet extension is not installed”, because the customer is required to install MetaMask wallet extension into browser to make payment. After the customer logs into the account, the web application will retrieve their wallet address, so smart contract can make actions such as sending loyalty points or NFT to the customer’s wallet addresses and making payment, and the wallet address and loyalty point token balance will be displayed on the top right corner of the website.

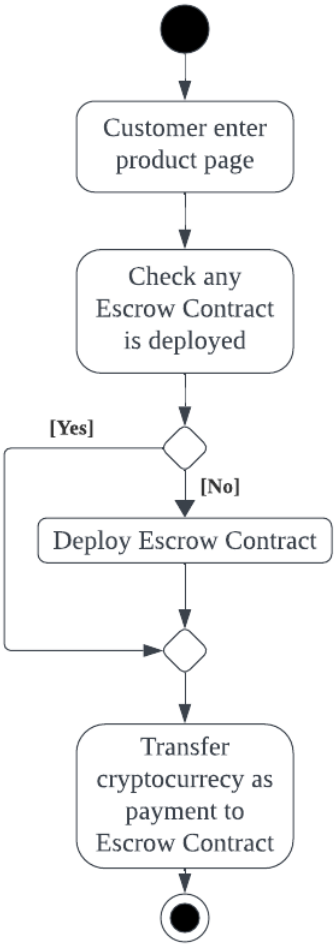


Figure 3.2.3.2 Activity Diagram of Purchasing Product

The figure above shows the process of customers purchasing products from the website. When the customer chooses to purchase a particular product, the system will check whether they have deployed an escrow contract before, if not, they will need to deploy an escrow contract by signing a transaction with their MetaMask wallet. After that, they will need to transfer funds as payment to the escrow contract by signing the pop-out MetaMask transaction request.

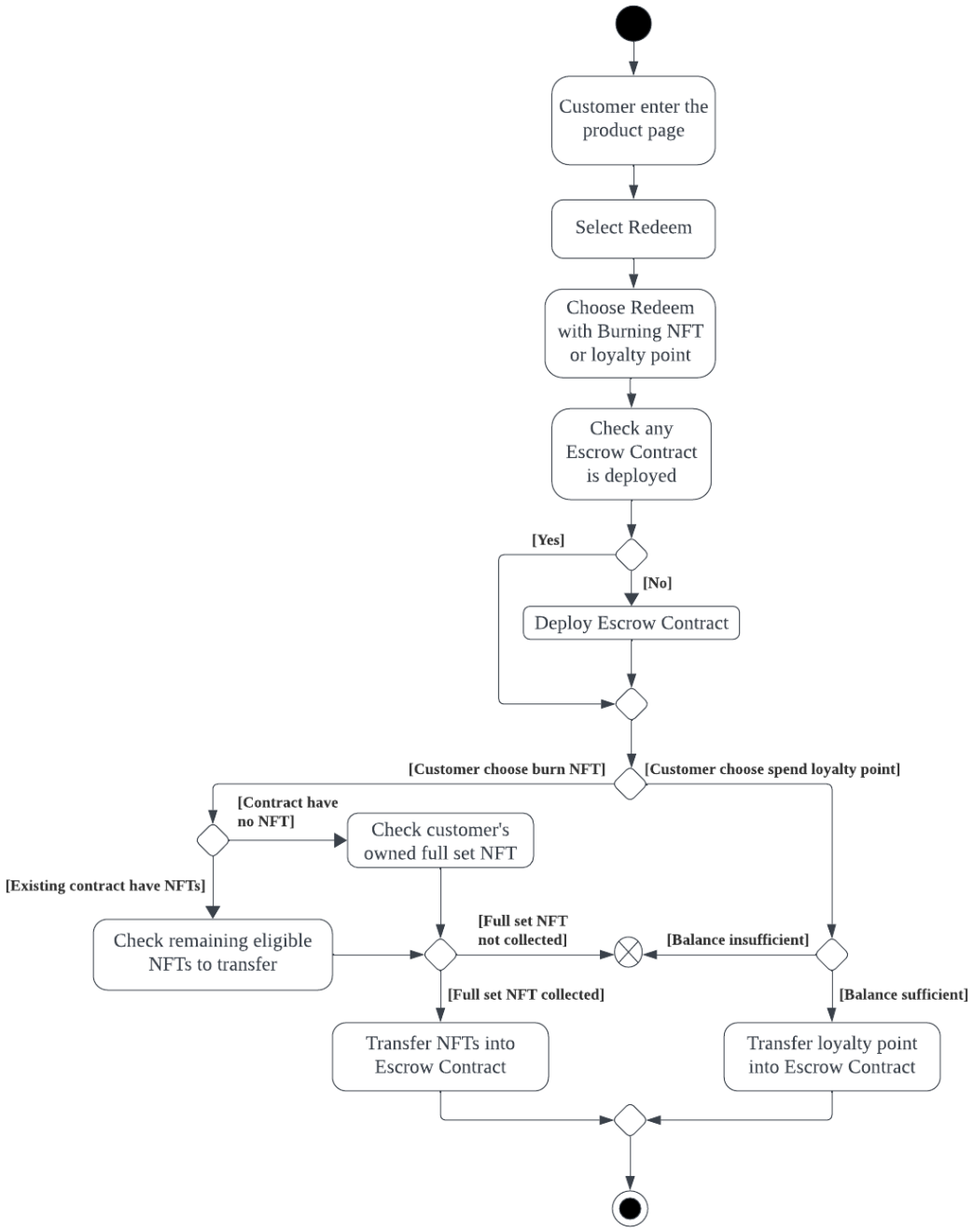


Figure 3.2.3.3 Activity Diagram of Redeeming Loyalty Reward

The figure above shows the process of customers redeeming loyalty rewards. There are two branches in this activity which is using collected NFT to redeem loyalty rewards or using loyalty points token to redeem loyalty rewards. Before redeeming the rewards, the system will check whether the customer has deployed an escrow service contract, if hasn't deployed, they will need to deploy one. After deploying, If the customer chooses to redeem loyalty rewards with the collected NFT, first the

backend will check whether they have collected a full set of NFT, if no, it will show nothing is redeemable and the activity will end, if yes and customer chooses to redeem, they are required to make a confirmation, if they confirm to redeem, their NFT will be transfer into the escrow contract.

Besides, if the customer wants to redeem loyalty rewards with their collected loyalty point token, same as the NFT part, the backend will check the customer loyalty point token balance, if the customer chooses to redeem, they required to make confirmation for the transaction if confirmed to redeem, their loyalty point token will be transfer into the escrow contract as well.

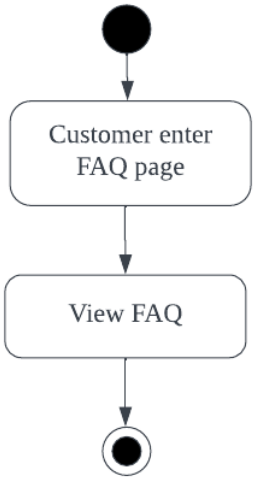


Figure 3.2.3.4 Activity Diagram of Viewing FAQ

The figure shows the activity of customers viewing the FAQ page. When customer enter the page, they can view those FAQ listed clearly.

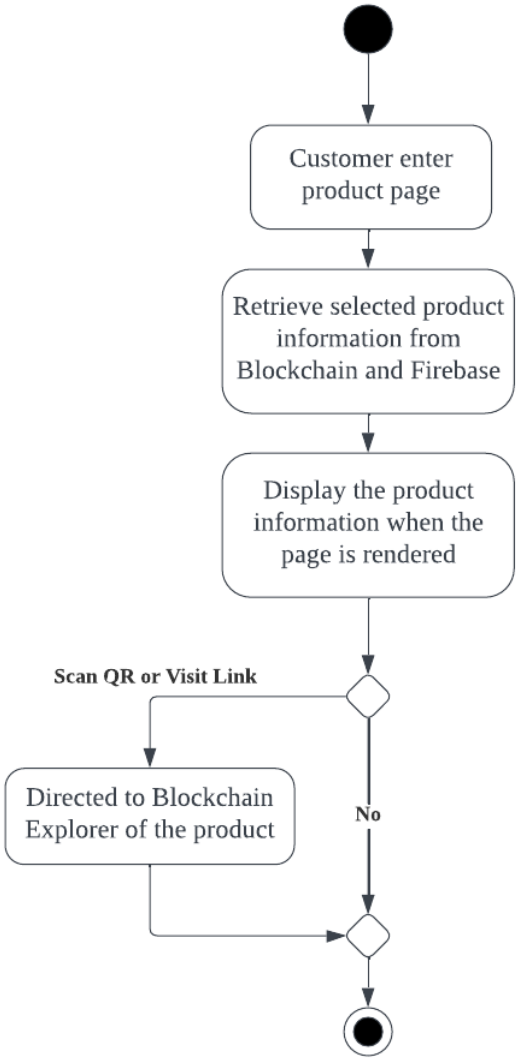


Figure 3.2.3.5 Activity Diagram of Viewing Product Information

The figure shows the activity of customers viewing the product's information. When the customer enters a selected product page, the backend will retrieve the product information from the Blockchain that was uploaded by the manufacturer and Firebase uploaded by the seller. After the product information is successfully retrieved, the product information will be displayed on the product page according to the layout set in the HTML file. Customer can also visit the block explorer of the product by scanning the QR code or visit the link "View on block explorer" in the bottom section of the product page.

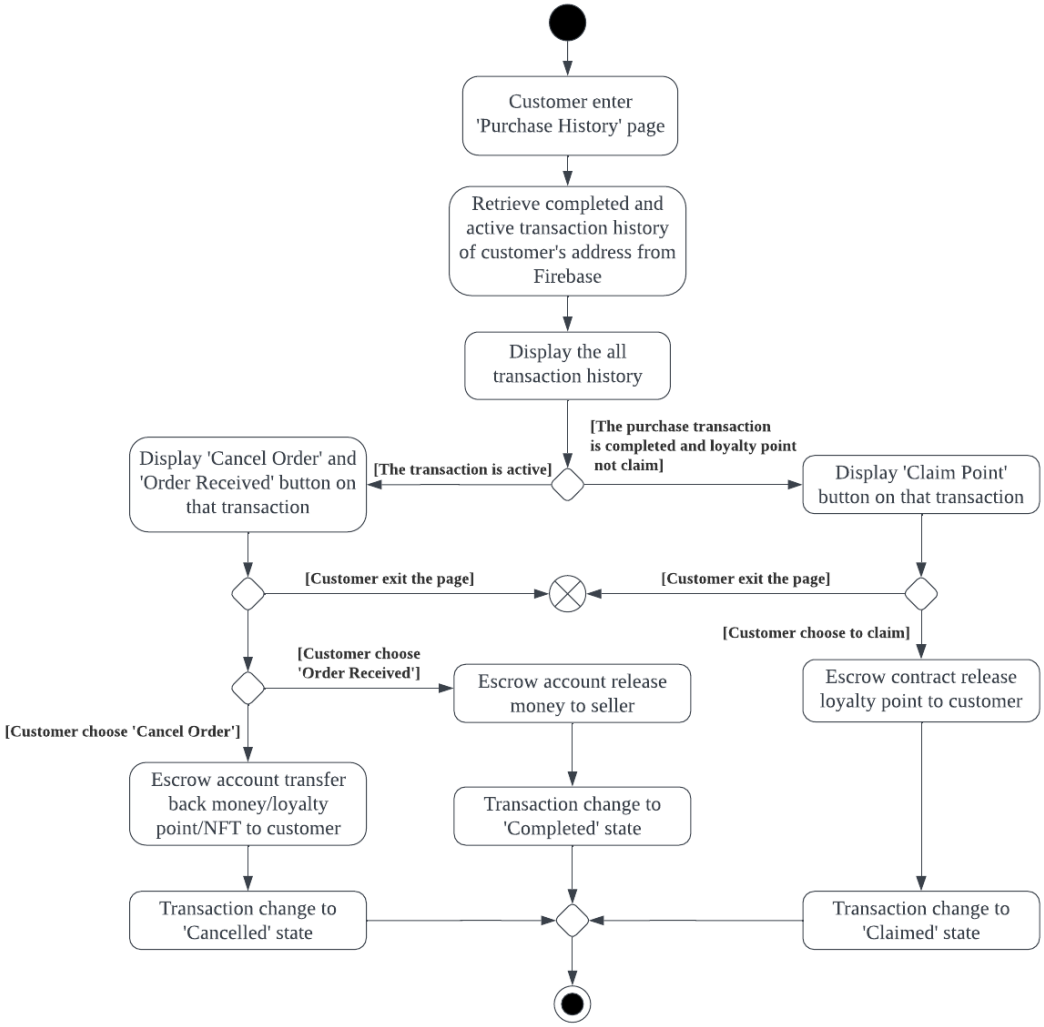


Figure 3.2.3.6 Activity Diagram of Viewing Purchasing History

The figure above shows the activity of customer viewing their purchasing history. When the customer enters the purchasing history page, the backend will retrieve all the completed and active transactions of the customer's wallet address from the Blockchain, and then display all the transactions on the page. If the transaction is active, there are two options for customers to choose "Cancel Order" or "Order Received", if customers choose to either one, they will need to make confirmation of their action. If the customer chooses to "Cancel Order", the fund will be transferred back to the customer from the escrow account, and the transaction status change to "Cancelled", If the customer chooses "Order Received", the money will be released to the seller. Besides, if customers choose the "Claim Point", loyalty point will be released to them.

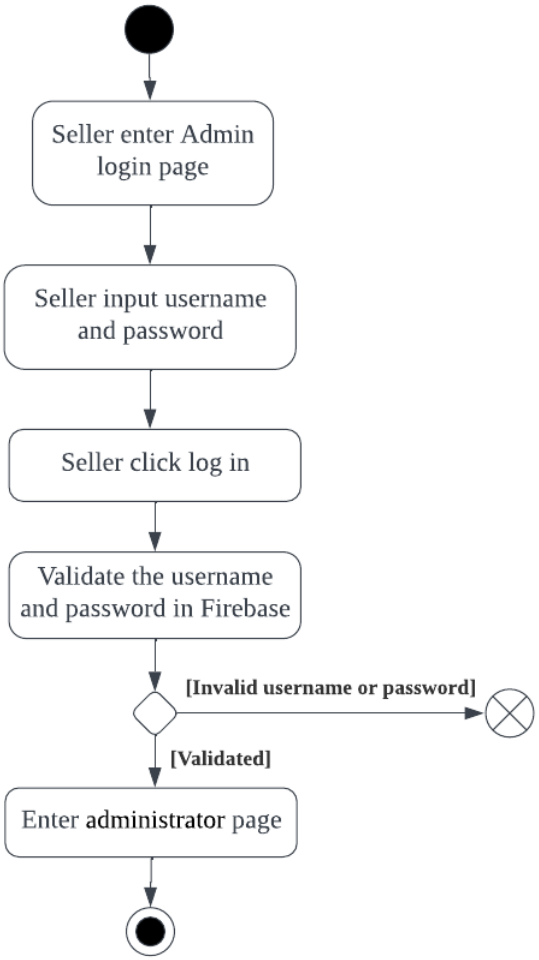


Figure 3.2.3.7 Activity Diagram of Login Administrator Account

The figure above shows the activity of the seller login into the administrator account. When sellers enter the admin login page from the homepage, they are required to input the username and password. After they click the log-in button, the backend will validate whether the entered username and password match the username and password that is stored in Firebase or not, if it is invalid, then the activity will end, elsse the seller will enter the administrator page for further configuration.

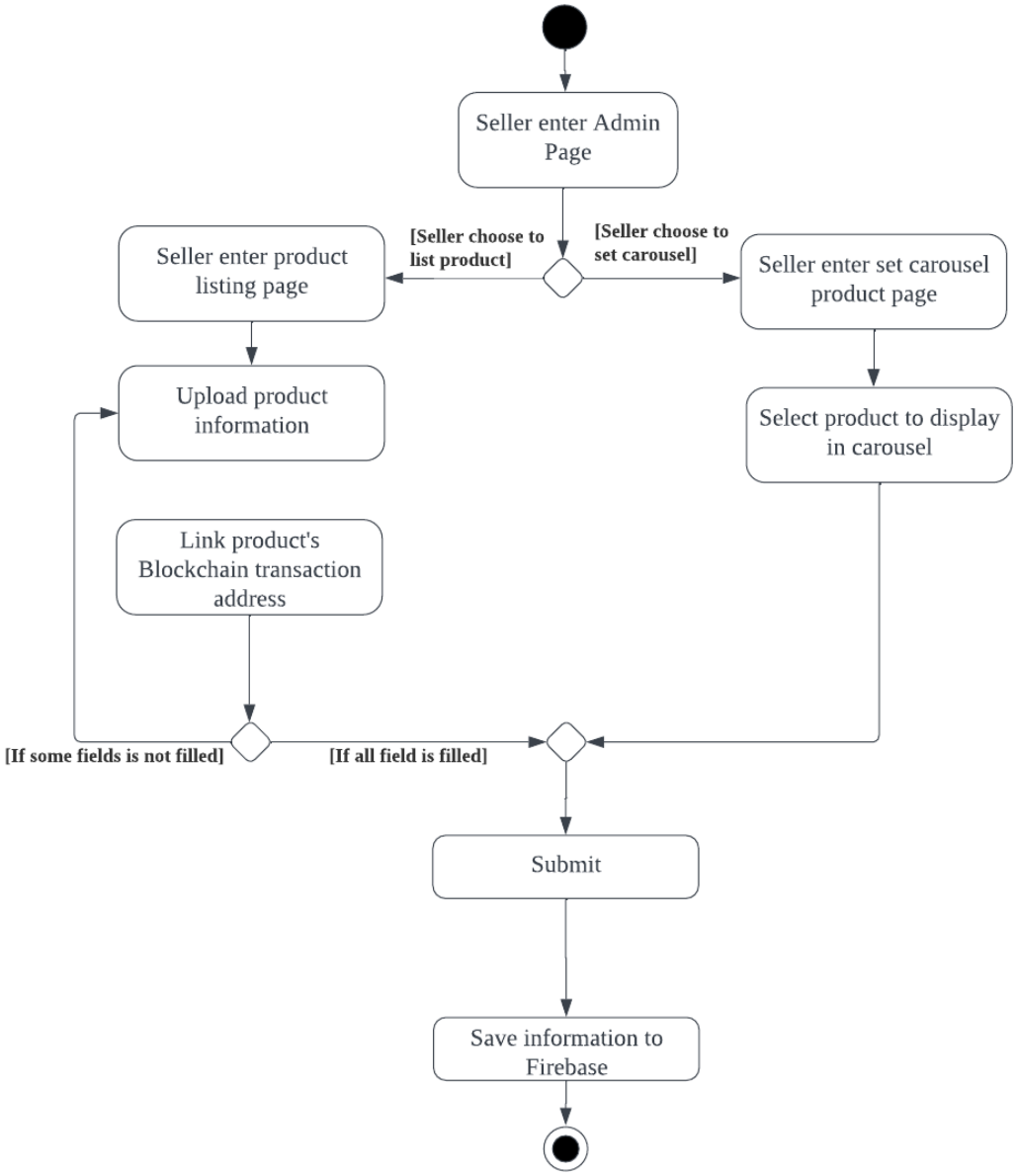


Figure 3.2.3.8 Activity Diagram of Configuring Website

The figure above shows the process of the seller configuring the website such as editing brand information such as about us, setting the loyalty reward information, and listing the product and link to the product's Blockchain address. After the seller completes their configuration, they need to confirm their action by clicking the submit button, so it will be saved into the Firebase for further usage.

3.3 System Pre-Authoring Analysis

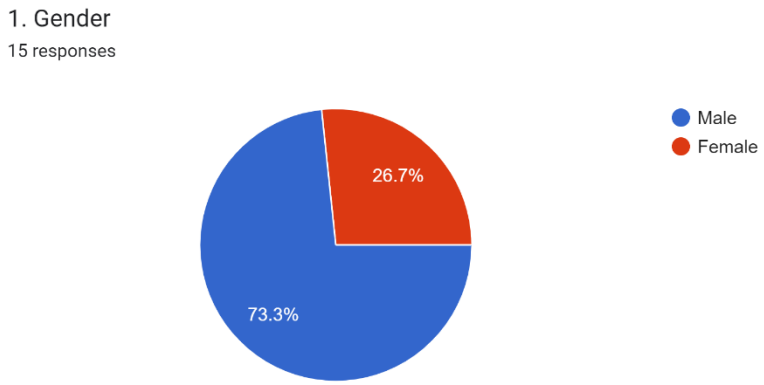


Figure 3.3.1 Survey Question 1

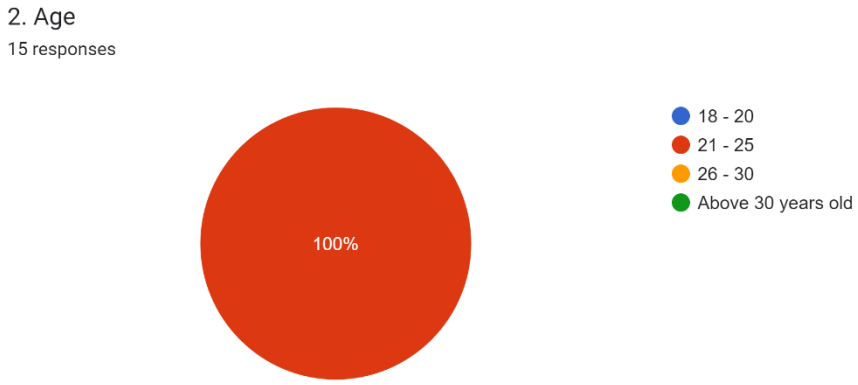


Figure 3.3.2 Survey Question 2

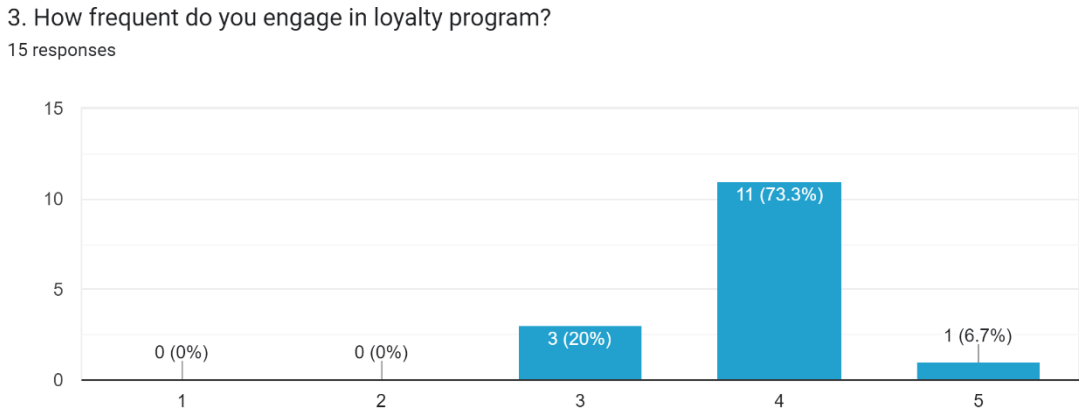


Figure 3.3.3 Survey Question 3

Figure 3.3.4 Survey Question 4

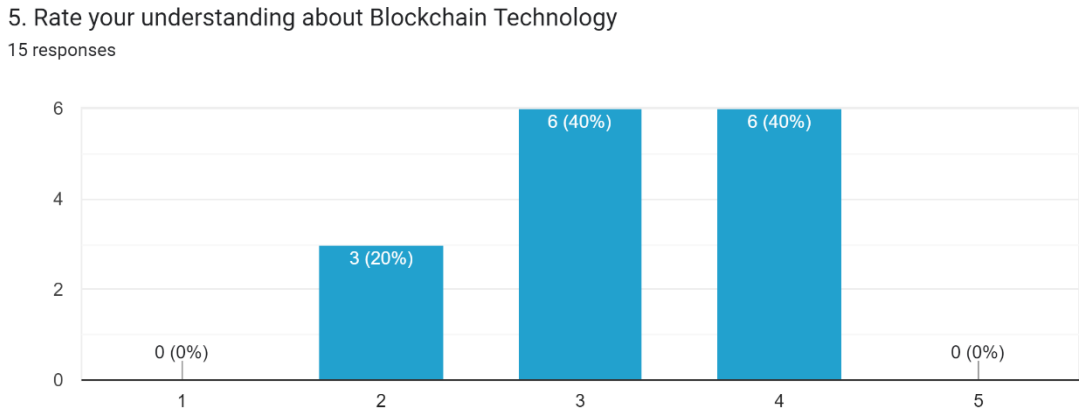


Figure 3.3.5 Survey Question 5

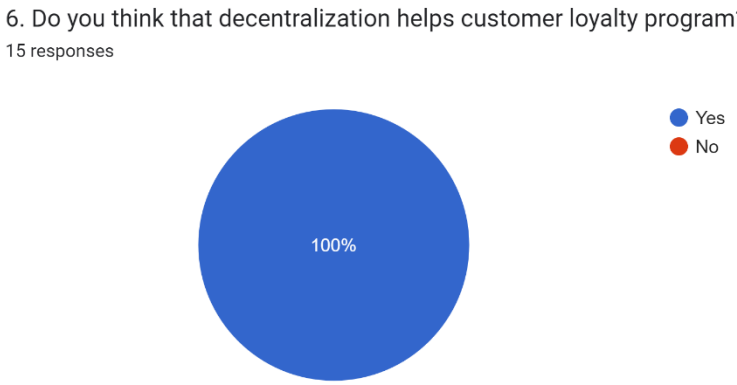


Figure 3.3.6 Survey Question 6

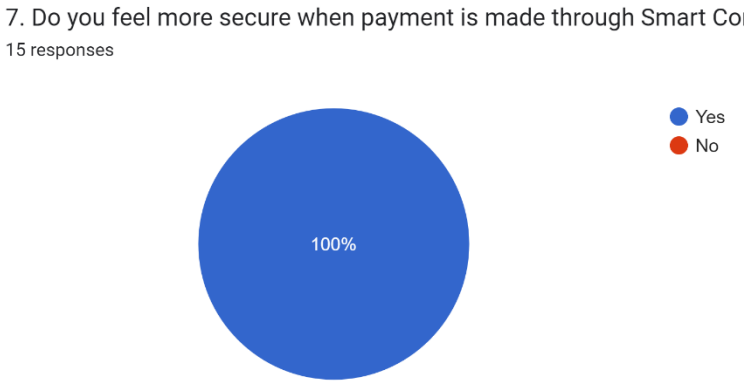


Figure 3.3.7 Survey Question 7

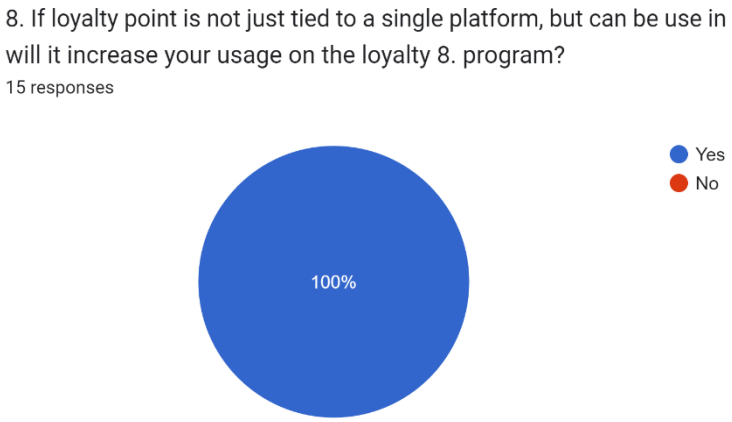


Figure 3.3.8 Survey Question 8

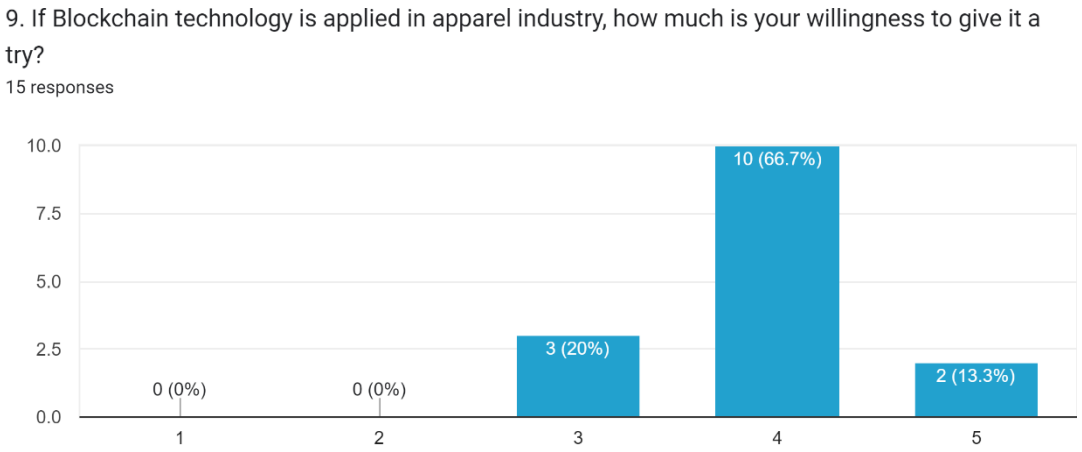


Figure 3.3.9 Survey Question 9

Based on the collected responses, the age of the respondents is in the range of 21-25 years old. Most of the respondents are frequently using loyalty programs in their daily lives. It may be due to the loyalty program providing them more value. They agree that a traditional apparel online shop and its customer loyalty program may cause their data privacy exposed, the payment security is not transparent, lack of flexibility in using loyalty points, and lack of flexibility in using loyalty points. 3 of the respondents, were not so familiar with Blockchain technology, another 6 of the respondents stated that they had the basic knowledge of Blockchain and the other 6 of the respondents showed that they were quite familiar with Blockchain. All of them agree that decentralization does help customer loyalty programs, they feel more secure when payment is made through Smart Contract instead of humans, and they will increase their usage of loyalty programs if the loyalty points are not just tied to a single platform. Lastly, most of them would like to the system with Blockchain technology a try.

CHAPTER 4: System Design

4.1 Flowchart

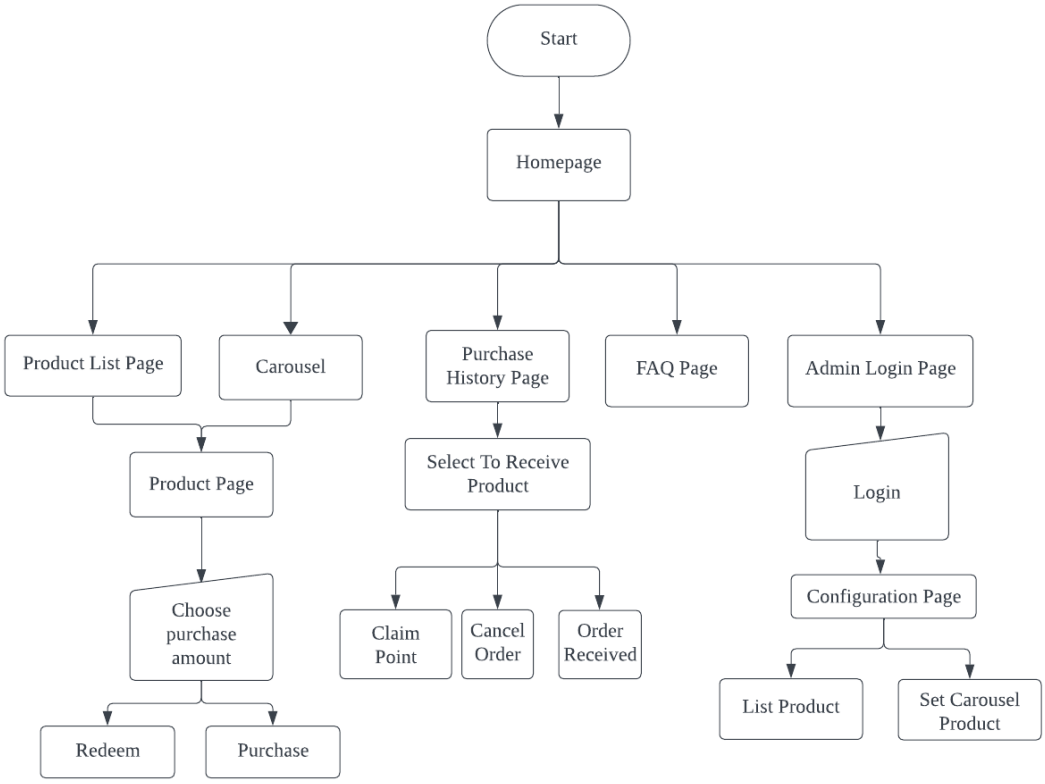


Figure 4.1.1 Flowchart of proposed CLP

Firstly, users will be directed to the homepage. Then, users have 5 navigation choices which include the Product List page, Carousel, Purchase History page, FAQ, and Admin Login page.

1. When users enter the Product page from the carousel or Product List page, they can adjust the purchase amount and make purchases or redeem the selected product.
2. When users enter the Purchase History page, they can choose to confirm the delivery of the purchased product and receive the loyalty points token and NFT or request a refund.
3. When users enter the FAQ page, they can view the FAQ of the CLP.
4. When users enter the Admin Login page, they are required to key in their username and password, therefore the backend can validate whether the user is the

seller. After successfully validated, the seller will enter the configuration page to configure items such as Listing Product, Set Carousel Product.

4.2 System Components Specifications

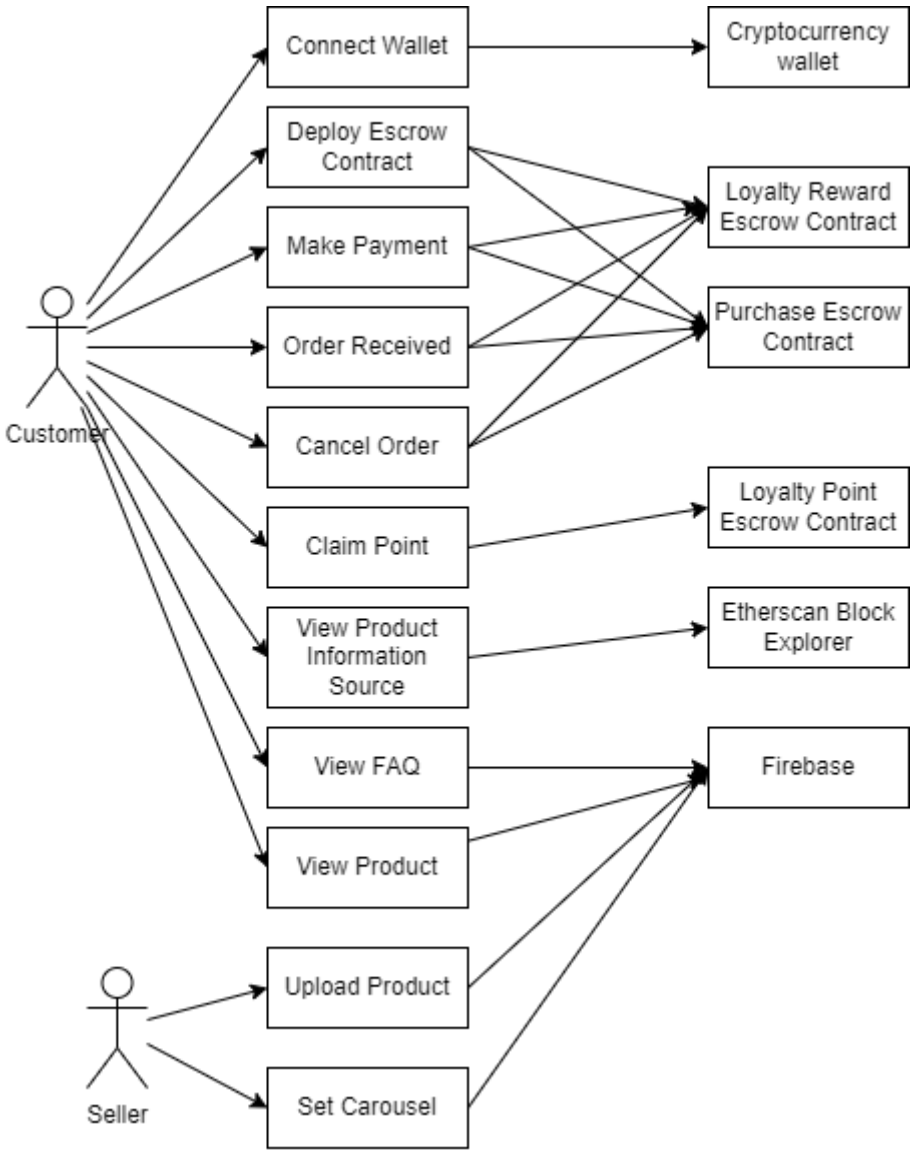


Figure 4.2.1 System Components Specifications Diagram

This project has two users which are customer and seller. There are 11 modules in total. Modules that customers will use include connect wallet which interacts with cryptocurrency wallet, make payment, order received, cancel order interacts with loyalty reward and purchase escrow contract, claim point interacts with loyalty point

escrow contract, view product information source interacts with Etherscan Block Explorer, view FAQ and product that interact with Firebase. For sellers, they will upload products and set a carousel module that interacts with Firebase.

4.3 System Components Interaction Operations

Connect Wallet

This module lets customers connect their cryptocurrency wallet with the system so that transactions such as payment, and contract deploying can be requested from the system through the web extension popout.

Deploy Escrow Contract

This module lets customers deploy their escrow contract to the blockchain so that it will hold the funds, loyalty point, or NFT until the transaction is completed so that it can eliminate the trust problem.

Make Payment

This module lets customers store their funds, and loyalty points inside the escrow contract, when the transaction is completed or canceled, the escrow contract will either release the holding to the seller or back to the customer.

Order Received

This module lets customers confirm their orders are received, so the holdings will be released to the seller and the customers can claim their loyalty points.

Cancel Order

This module lets customers cancel their orders, so the holdings will be released back to the customers.

Claim Point

This module lets customers claim their loyalty points after they have confirmed the delivery of the order. They can use the loyalty point to redeem products from the system.

View Product Information Source

This module lets customers view the product information source in the blockchain explorer, Etherscan. This information is sent by a third party that includes the product life cycle information.

View FAQ

This module lets customers view the FAQ of the loyalty program or cryptocurrency wallet using instructions such as how to install a cryptocurrency wallet. This data is pulled from the Firebase.

View Product

This module lets customers view a particular product that they selected from the carousel or product list. Inside the page will show information about the selected product such as available size and colour. This data is pulled from the Firebase.

Upload Product

This module lets sellers upload product information such as product name, description, and price into Firebase.

Set Carousel

This module lets the seller choose which product to display in the carousel on the homepage. After the seller has chosen the products to display, it will store those data in Firebase.

CHAPTER 5: System Implementation

5.1 Hardware setup

Description	Specifications
Model	Predator PT315-51
Processor	Intel(R) Core(TM) i5-9300H
Operating System	Windows 11 Home
Graphic	NVIDIA GeForce GTX 1650
Memory	16GB DDR4 RAM
Storage	475GB SAMSUNG SSD

Table 5.1.1 Specifications of Laptop

5.2 Software setup

5.2.1 Visual Studio Code

Hardware Requirement	• Minimum 800 MB or hard disk space • GHz or faster processor • 1 GB of RAM
Platforms	• Windows 10 and 11 (64-bit) • macOS versions with Apple security update support. This is typically the latest release and the two previous versions. • Linux (Debian): Ubuntu Desktop 20.04, Debian 10 • Linux (Red Hat): Red Hat Enterprise Linux 8, Fedora 36

Table 5.2.1.1 Hardware Requirements and Platforms of Visual Studio Code

5.3 Setting and configuration

Node.js

First of all, I want to create a web application that is server-side to ensure security.

1. The first step is installing Node.js from the link below.
   https://nodejs.dev/en/download/

   To test whether the Node.js is installed successfully, enter the command below in the command prompt, if it responds with the version, then Node.js is installed successfully.

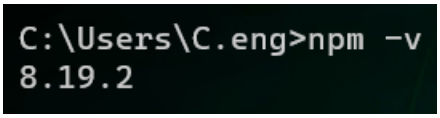


Figure 5.3.1 Check Node.js version

2. Then create a directory named “ENGA ”for the new web application with the command below.

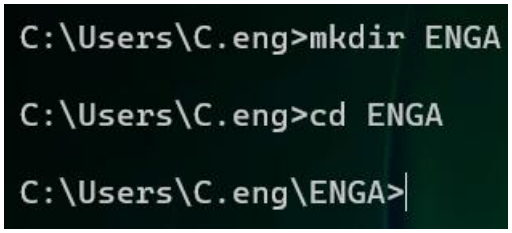


Figure 5.3.2 Create Node.js directory

3. Followed by initializing to set up a new or existing npm package with the name “enga” and entry point “index.js”.

```
C:\Users\C.eng\ENGA>npm init
This utility will walk you through creating a package.json file.
It only covers the most common items, and tries to guess sensible defaults.

See `npm help init` for definitive documentation on these fields
and exactly what they do.

Use `npm install <pkg>` afterwards to install a package and
save it as a dependency in the package.json file.

Press ^C at any time to quit.
package name: (enga)
version: (1.0.0)
description:
entry point: (index.js)
test command:
git repository:
keywords:
author:
license: (ISC)
About to write to C:\Users\C.eng\ENGA\package.json:

{
  "name": "enga",
  "version": "1.0.0",
  "description": "",
  "main": "index.js",
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1"
  },
  "author": "",
  "license": "ISC"
}
```

Figure 5.3.3 Initialize new directory

4. After the index.js is configured, start the server with the command below under the directory “ENGA” created in the first step.

```
C:\Users\C.eng\ENGA>node index.js
App listening on port 3000!
```

Figure 5.3.4 Run Node.js Server

Deploy ERC-20 Token

1. Create Folder

2. In cmd direct to the created folder, and run below command:

- npm init
- npm install --save-dev hardhat
- npx hardhat
- npm install dotenv --save
- npm install @openzeppelin/contracts
- npm install --save-dev @nomiclabs/hardhat-ethers "ethers@^5.0.0"
- mkdir contracts
- mkdir scripts

3. Create .sol file

```
//SPDX-License-Identifier: Unlicense
pragma solidity ^0.8.20;

import "@openzeppelin/contracts/token/ERC20/ERC20.sol";  // Ope

contract EngApparel is ERC20 {
    uint constant _initial_supply = 1000000000000 * (10**18);

    /* ERC 20 constructor takes in 2 strings, feel free to chan
    constructor() ERC20("EngApparel", "ENGA") {
        _mint(msg.sender, _initial_supply);
    }
}
```

Figure 5.3.5 Create .sol file

4. Create .env file and store API, Private key and Address

```
API_URL="https://eth-sepolia.g.alchemy.com/v2/xxxxxxxxxxxx"
PRIVATE_KEY="xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx"
PUBLIC_KEY="xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx"
```

Figure 5.3.6 Create .env file

Those “x” will be replaced with the real API, Private key and Public key

5. Update hardhat.config.js

```
require('dotenv').config();
require("@nomiclabs/hardhat-ethers");

const { API_URL, PRIVATE_KEY } = process.env;

module.exports = {
  solidity : "0.8.20",
  defaultNetwork : "sepolia",
  networks : {
    hardhat: {},
    sepolia: {
      url: API_URL,
      accounts: [`0x${PRIVATE_KEY}`]
    }
  }
};
```

Figure 5.3.7 Update hardhat.config.js

5. In cmd, direct to the directory of the folder created and run "**npx hardhat compile**".

6. Write Deploy Script

```
async function main() {
    const [deployer] = await ethers.getSigners();

    console.log("Deploying contracts with the account:", deployer.address);

    const weiAmount = (await deployer.getBalance()).toString();

    console.log("Account balance:", (await ethers.utils.formatEther(weiAmount)));

    const Token = await ethers.getContractFactory("EngApparel");
    const token = await Token.deploy();

    console.log("Token address:", token.address);
  }

  main()
    .then(() => process.exit(0))
    .catch((error) => {
      console.error(error);
      process.exit(1);
  });
```

Figure 5.3.8 Write Deploy Script

7. In cmd, run "**npx hardhat run scripts/deploy.js --network sepolia**"

8. After successfully deploying the contract, a message "Deploying contracts with the account: [Token Address]" will be displayed. To get more information about the token, browse https://sepolia.etherscan.io/ and search for the [Token Address] in the search bar.

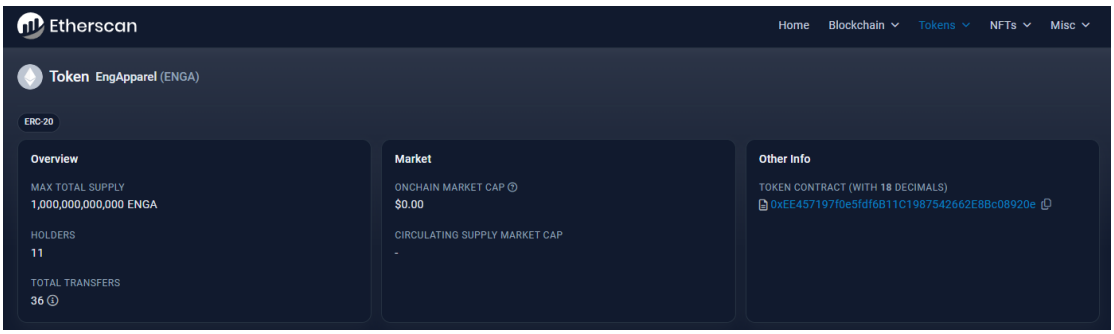


Figure 5.3.9 Deployed Token transaction page on Etherscan Blockchain Explorer

5.4 System Operation (with Screenshot)

In this section, there will be series of screenshots of how customer and seller can interact and what they will see during the usage of the system.

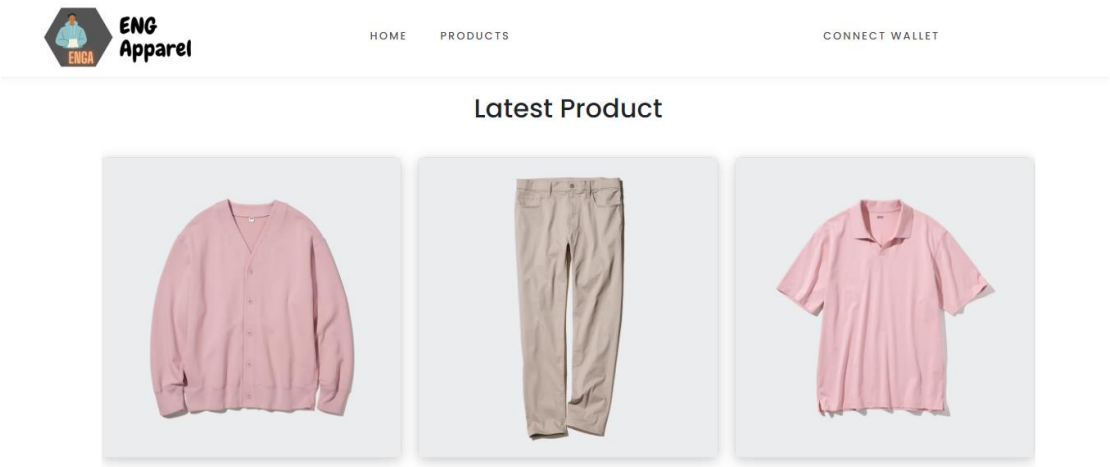


Figure 5.4.1 Homepage

This is the homepage of the system, whenever the user enters the website, this is the first page they will see.

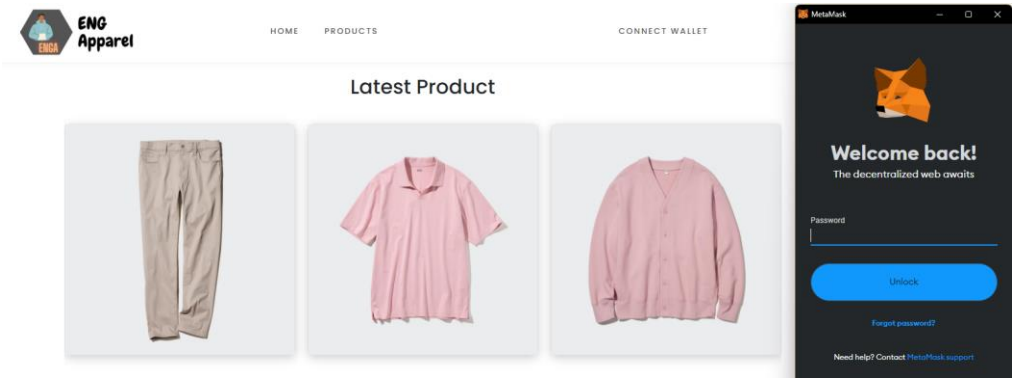


Figure 5.4.2 MetaMask Web Extension Popout

Whenever users enter any pages except the admin login and configuration page or users click on the “Connect” button, the web extensions will pop out to request for sign-in. This will only occur when users have installed MetaMask web extensions in their browsers.

Figure 5.4.3 Navigation Bar After Logged In

After users have inputted their account info, the system will retrieve the info of their account such as their wallet balance and address, and it will display on the navigation bar.

Figure 5.4.4 Footer

At the bottom of the homepage, product list page, product page, and purchase history page, their a footer that contains the link to the admin login page and FAQ.

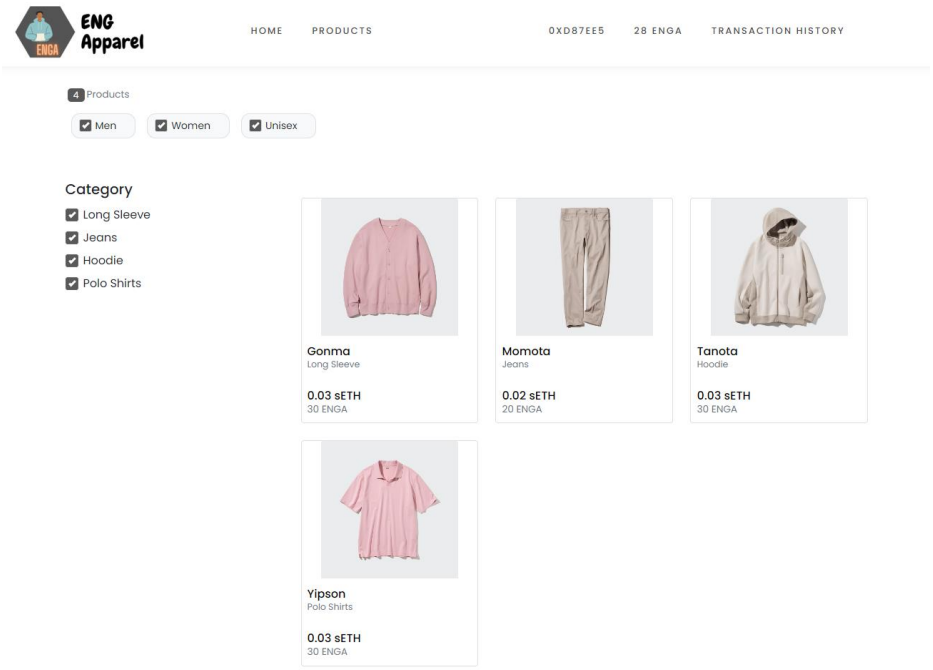


Figure 5.4.5 Product List Page

When users clicked on “Products” on the navigation bar, user will be redirected to a page that listed all the products. In the page, there will be filter for category and

gender. Users will be redirected to the product page when they click on the product listed in the product list page.

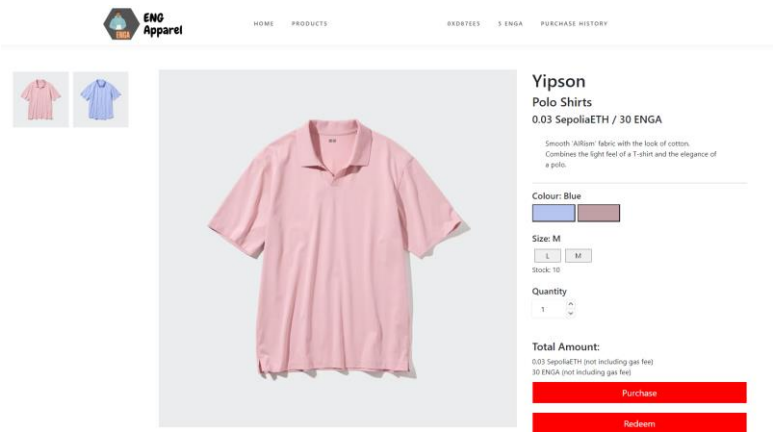


Figure 5.4.6 Product Page

After users have clicked on a product from the product list or carousel, they will be redirected to the selected product page. The page will contain product information such as available colour, size, stock left, product description, purchase button, redeem button, etc.

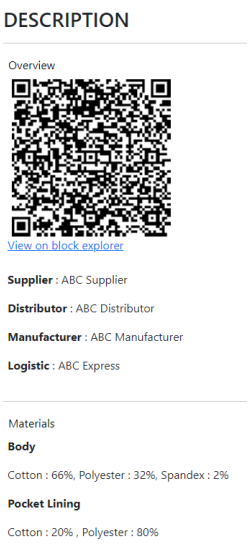


Figure 5.4.7 Product Description

In the product description section will contain a QR code and a link that will redirect users to the Etherscan Blockchain Explorer that contains the product lifecycle information.

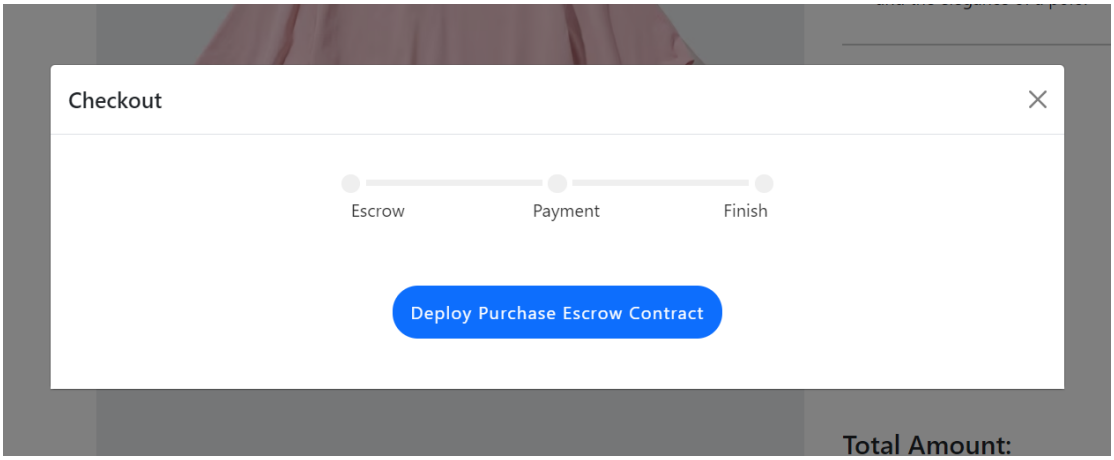


Figure 5.4.8 Modal of Deploying Purchase Escrow Contract

When users click on the “Purchase” button, a modal will pop out and it will check whether the user has deployed any Escrow Contract before, if no, then the progress bar will start from ‘Escrow”, which means that users need to deploy a escrow contract before proceeding to make payment.

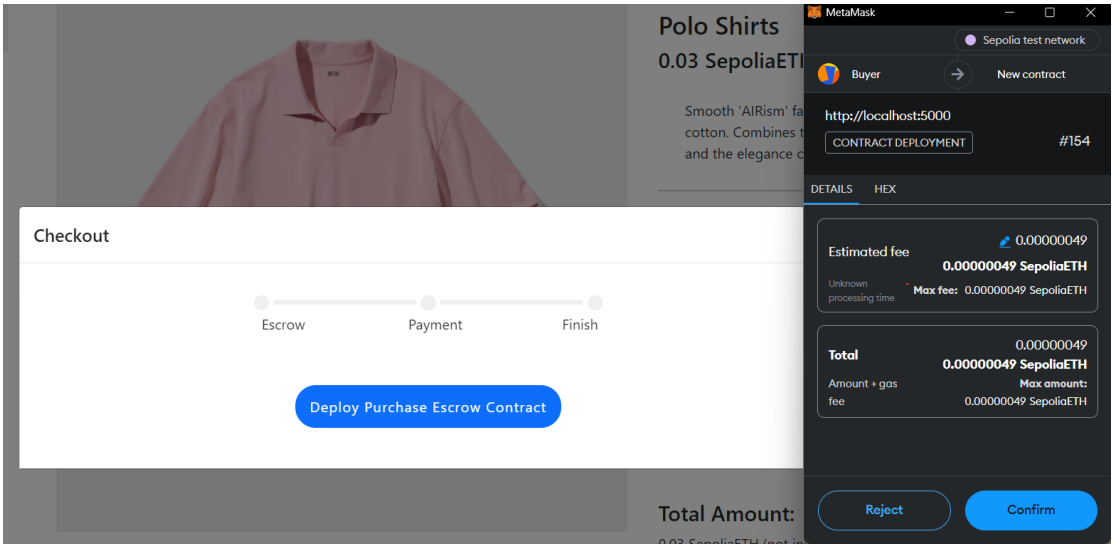


Figure 5.4.9 MetaMask Web Extension Popout for Deploying Purchase Escrow Contract

After clicking the “Deploy Purchase Escrow Contract” a MetaMask web extension will pop out to request users sign the transaction of deploying the contract.

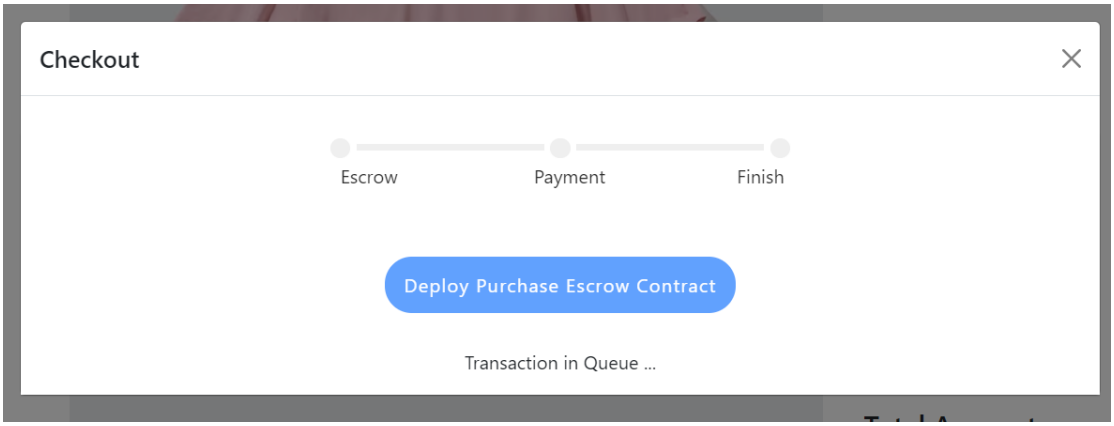


Figure 5.4.10 Modal of Deploying Purchase Escrow Contract

When the transaction is ongoing, the button will be disabled.

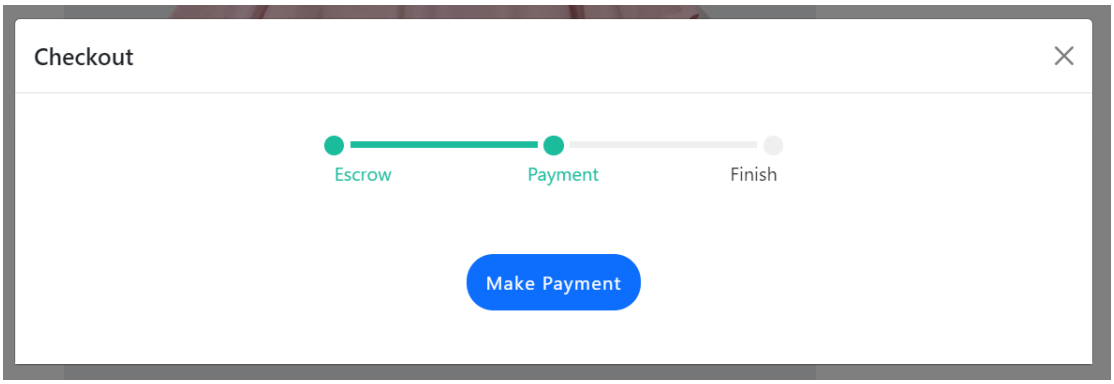


Figure 5.4.11 Modal of Make Payment for Purchase

After the contract is deployed, the progress bar proceeds to “Payment”, and the button will change to “Make Payment”.

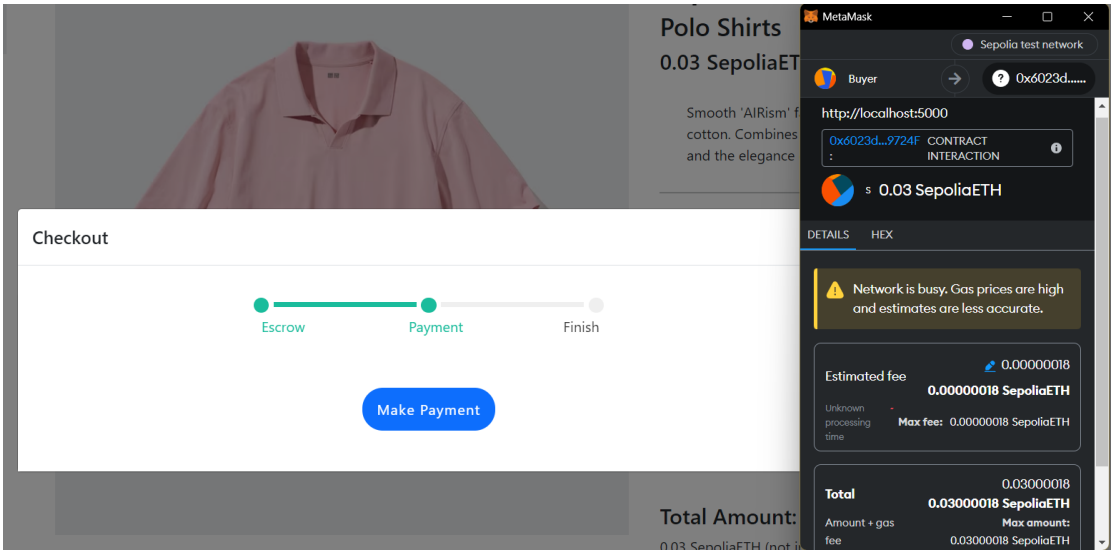


Figure 5.4.12 MetaMask Web Extension Popout for Making Payment for the Purchase

After clicking the "Make Payment" a MetaMask web extension will pop out to request users sign a transaction making a payment.

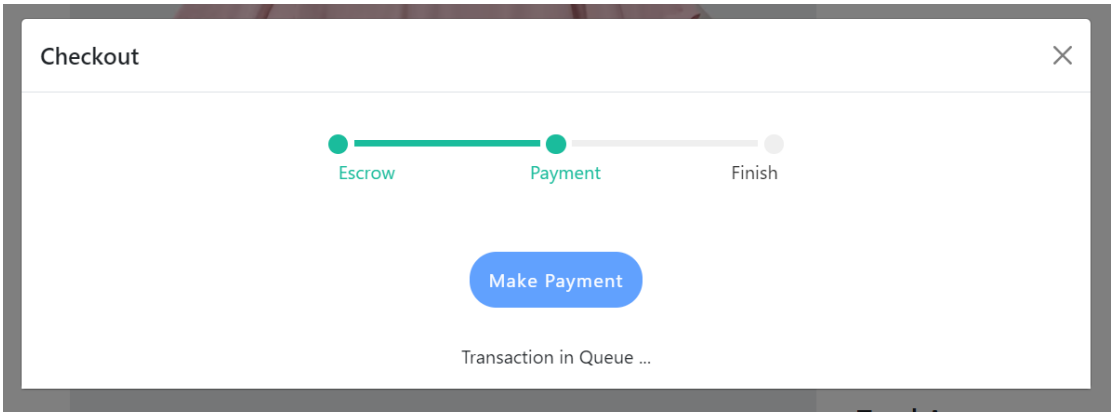


Figure 5.4.13 Modal of Making Payment for the Purchase

When the transaction is ongoing, the button will be disabled.

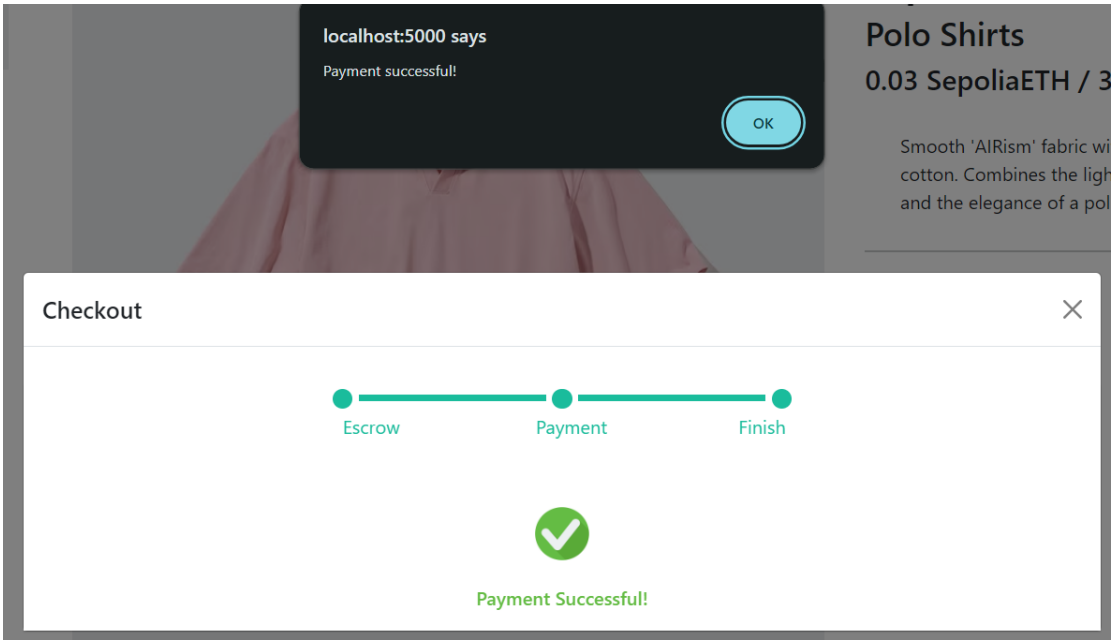


Figure 5.4.14 Purchase Transaction Completed

After the transaction is done, the progress bar will proceed to the “Finish”, and the modal content will display “Payment Successful”, and an alert dialog will appear.

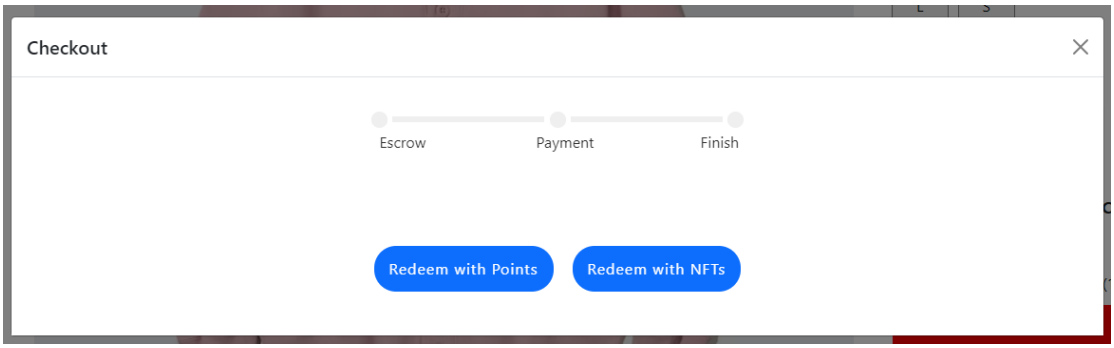


Figure 5.4.15 Modal of Selecting Redeem Loyalty Reward with Loyalty Points or NFTs

When user clicked on “Redeem”, a modal with selection “Redeem with Points” and “Redeem with NFTs” will pop out.

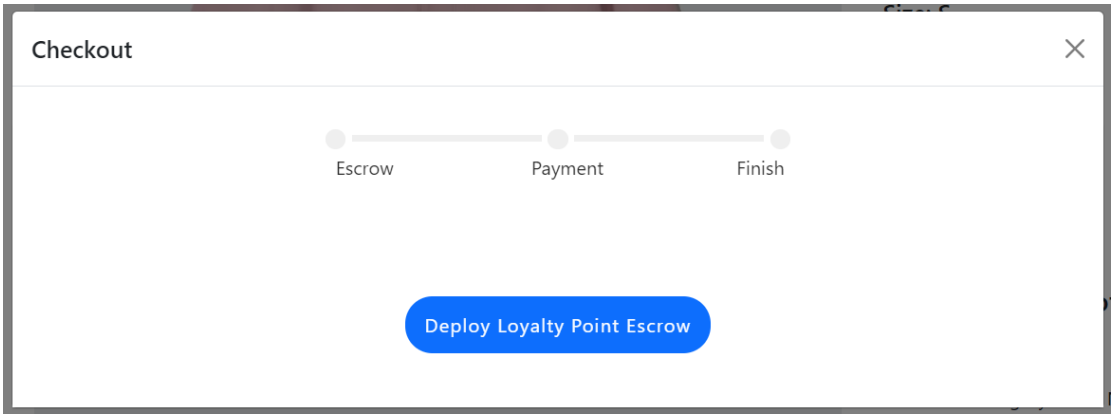


Figure 5.4.16 Modal of Deploy Loyalty Point Reward Escrow Contract

Same process as the Purchase Escrow Contract, when users click on the "Redeem with Points" button, the system will check whether the user has deployed any Escrow Contract before, if no, then the progress bar will start from "Escrow", which means that users need to deploy an escrow contract before proceeding to make payment.

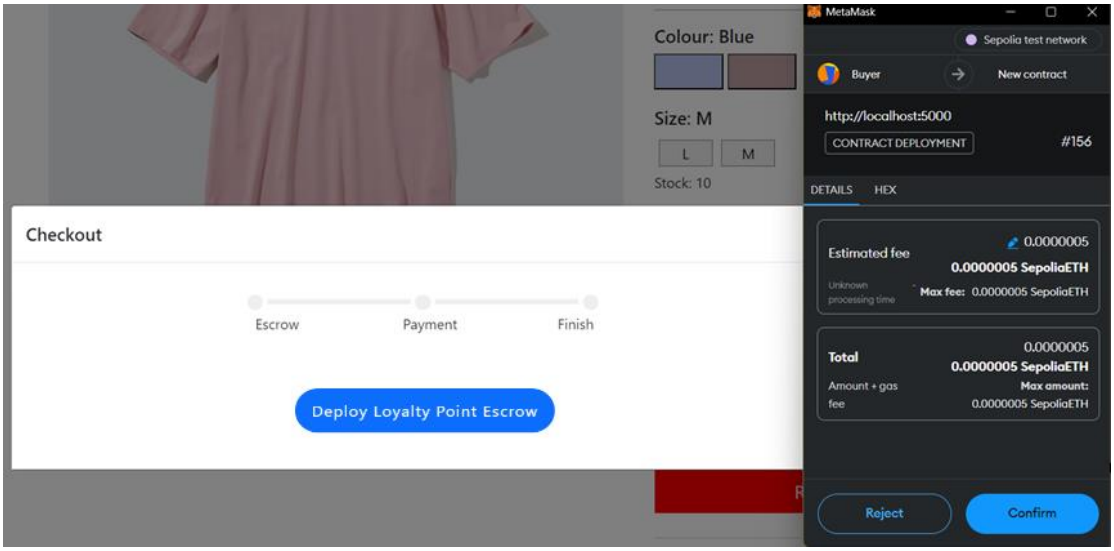


Figure 5.4.17 MetaMask Web Extension Popout for Deploying Loyalty Point Reward Escrow Contract

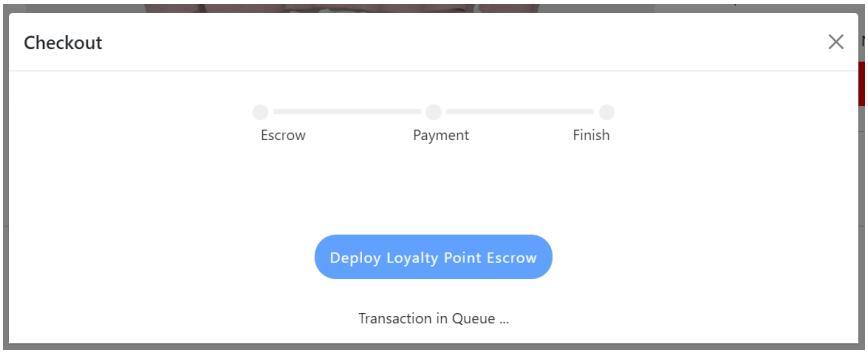


Figure 5.4.18 Modal of Deploying Loyalty Point Reward Escrow Contract

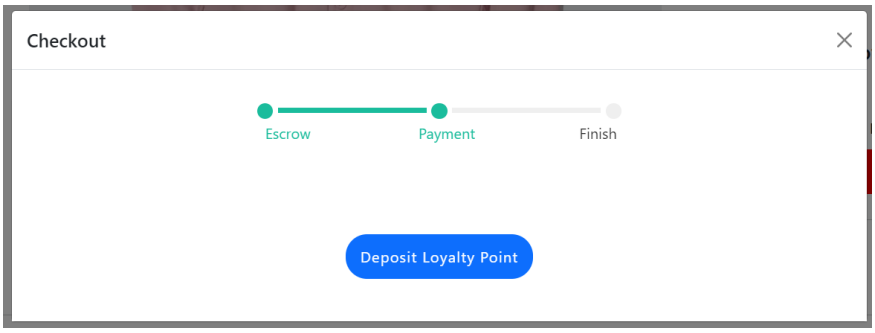


Figure 5.4.19 Modal of Deposit Loyalty Point for Loyalty Point Reward

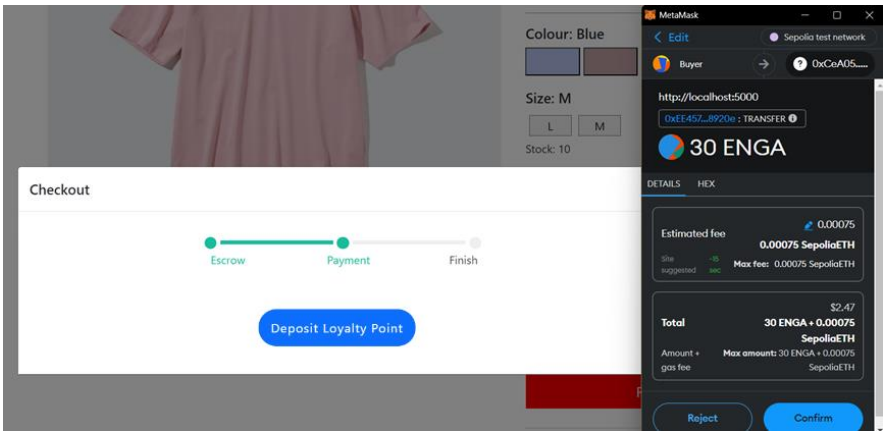


Figure 5.4.20 MetaMask Web Extension Popout for Depositing Loyalty Point for the Loyalty Point Reward

For the Loyalty Reward, the thing different from the Purchase is the fund needed to transfer is not SepoliaETH, but ENGA which is the loyalty point.

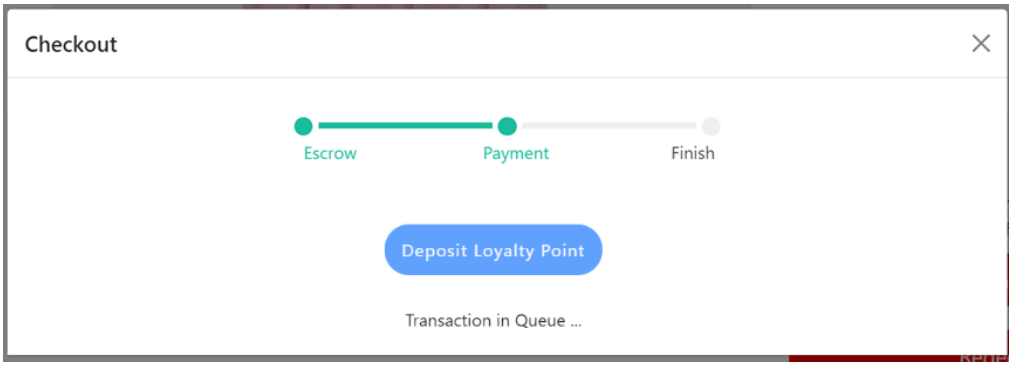


Figure 5.4.21 Modal of Depositing Loyalty Point for the Loyalty Point Reward

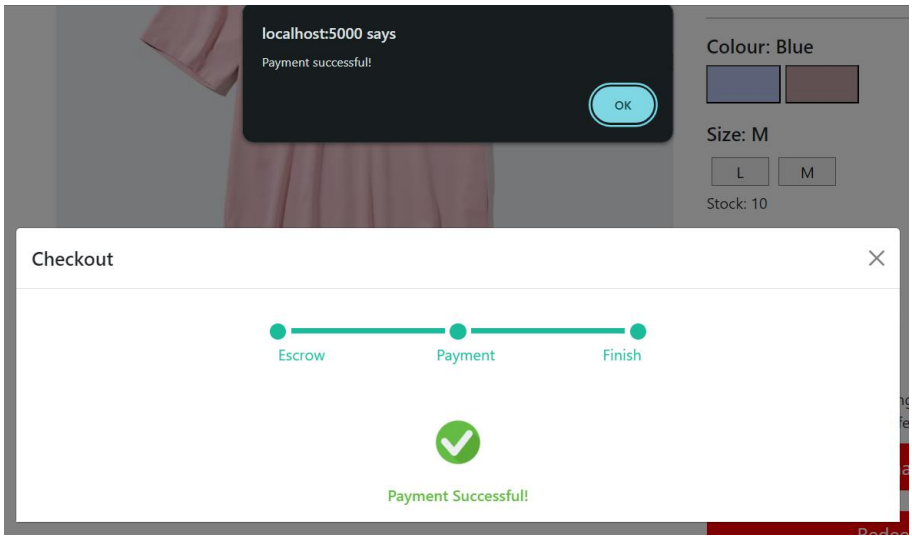


Figure 5.4.22 Redeem Loyalty Point Reward Transaction Completed

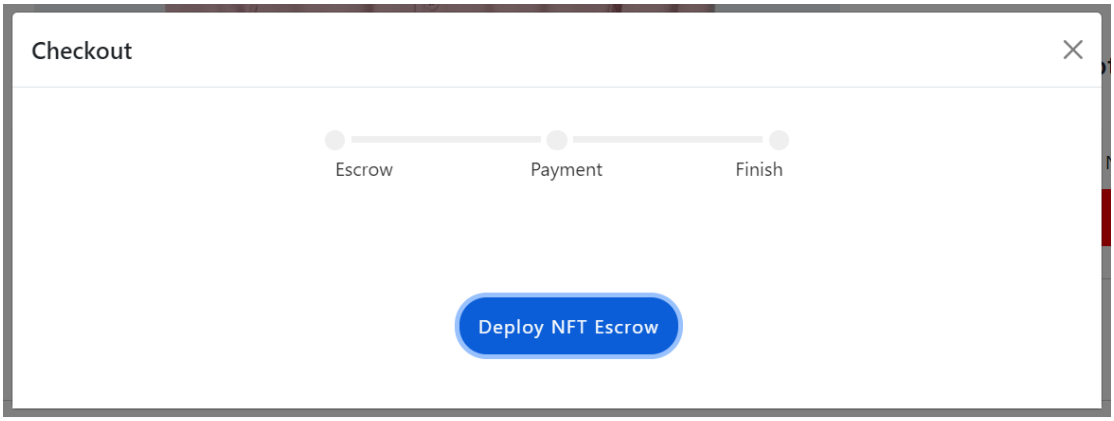


Figure 5.4.23 Modal of Deploying NFT Reward Escrow Contract

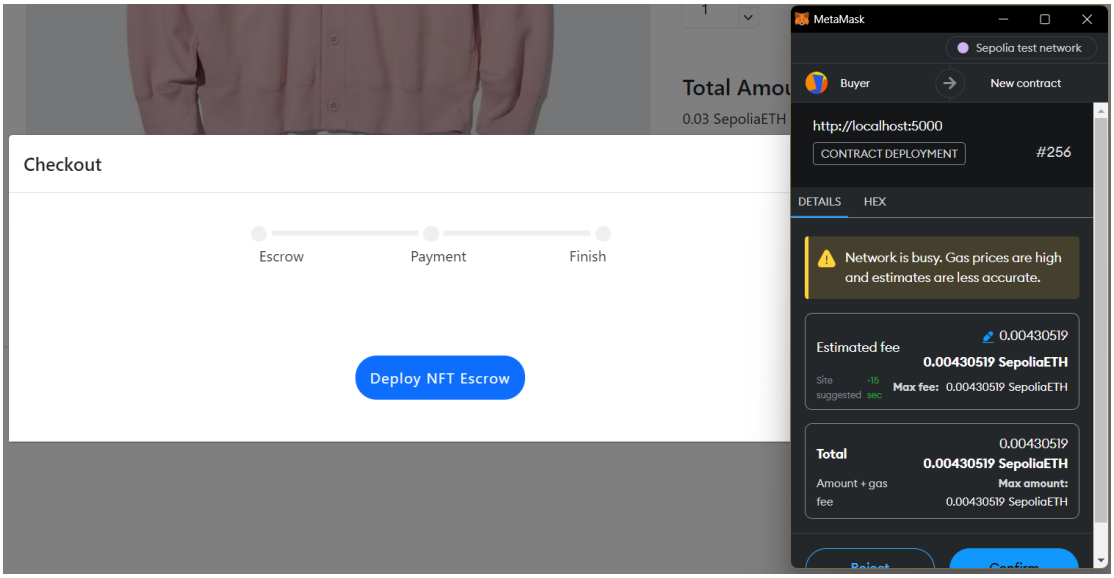


Figure 5.4.24 MetaMask Web Extension Popout for Deploying NFT Reward Escrow Contract

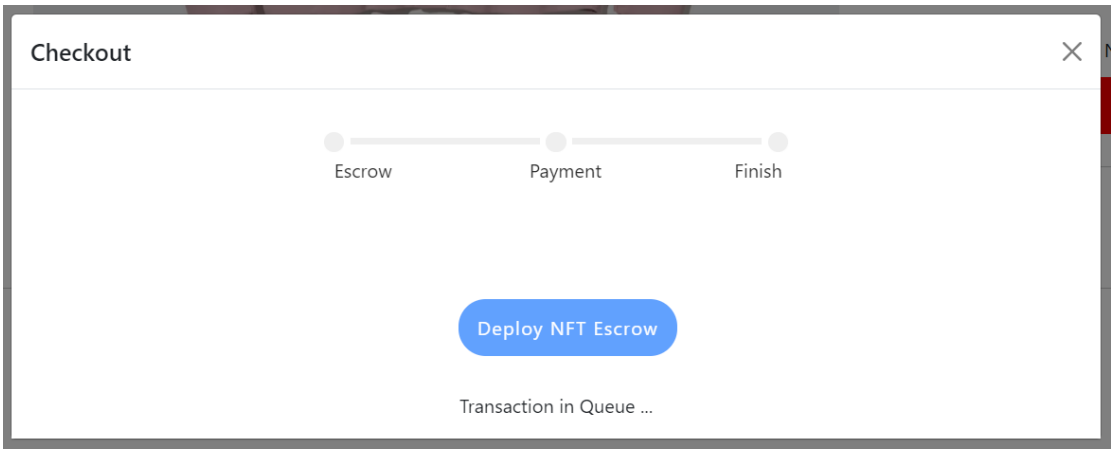


Figure 5.4.25 Modal of Deploying NFT Reward Escrow Contract

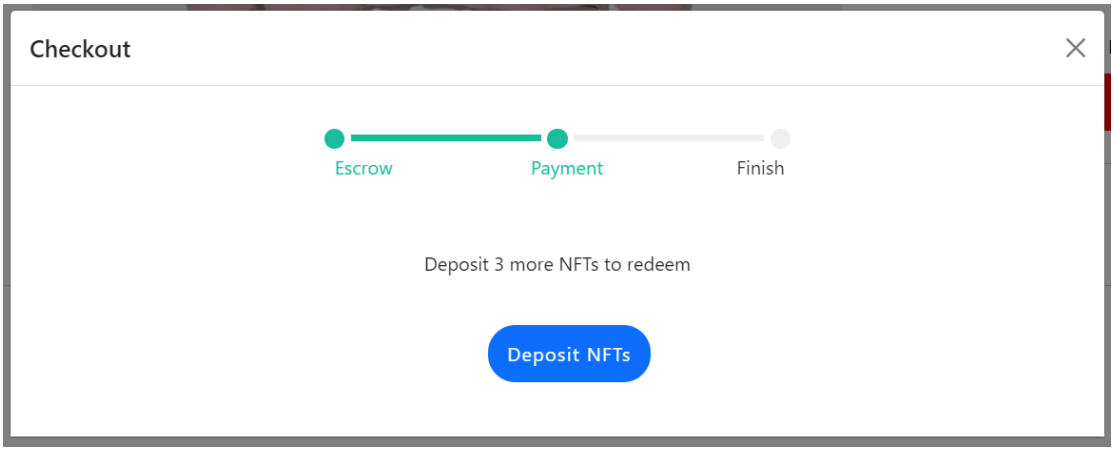


Figure 5.4.26 Modal of Deposit NFTs for NFT Reward

In the centre of the modal, the number of NFTs required to deposit will be shown.

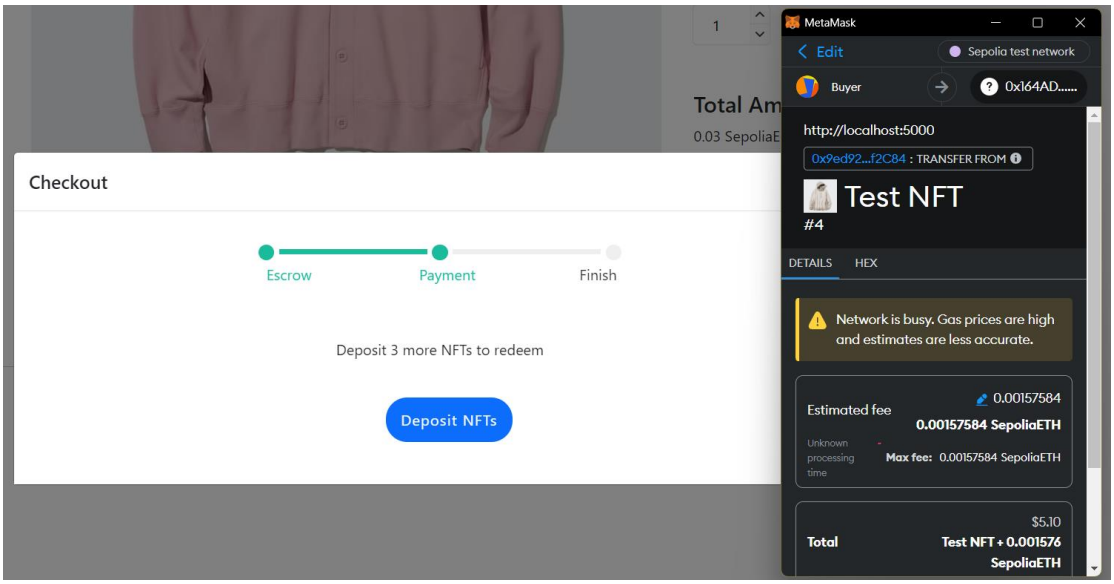


Figure 5.4.27 MetaMask Web Extension Popout for Depositing NFTs for the NFT Reward Escrow Contract

The extension will pop out three times to request user transfer their NFTs to the escrow contract.

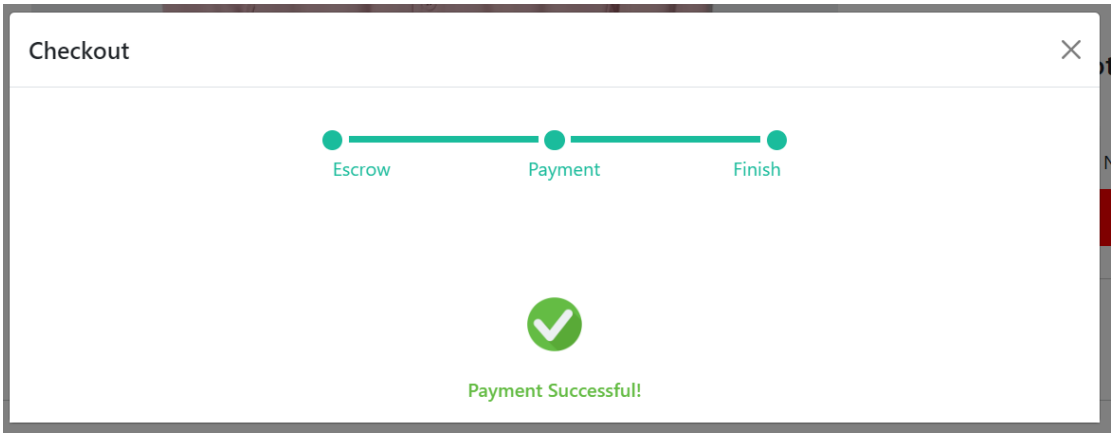


Figure 5.4.28 Redeem NFT Reward Transaction Completed

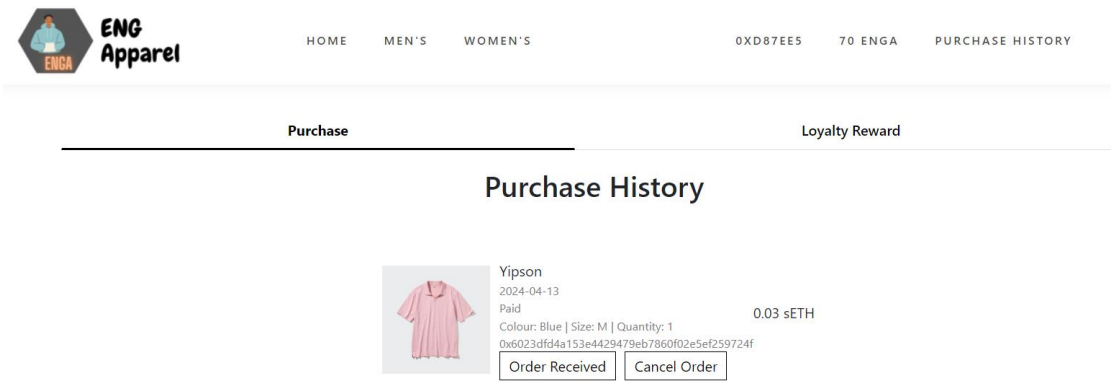


Figure 5.4.29 Transaction History Page

In the transaction history page, all transactions made by the user will be shown up here, including the purchase and the loyalty reward redemption.

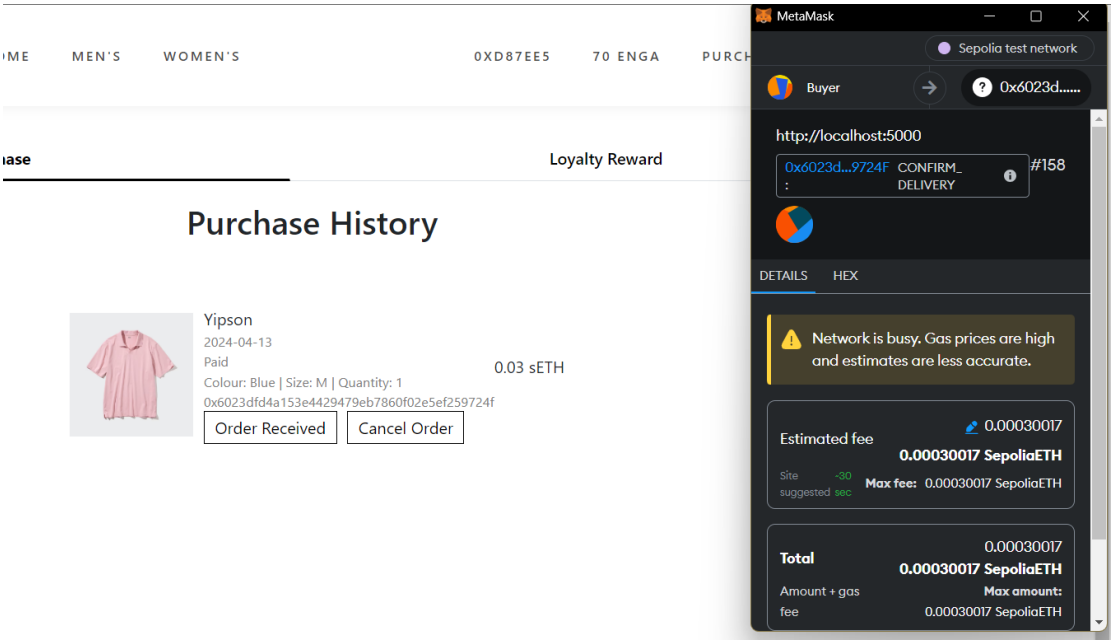


Figure 5.4.30 MetaMask Web Extension Popout for Confirming the Order is Received

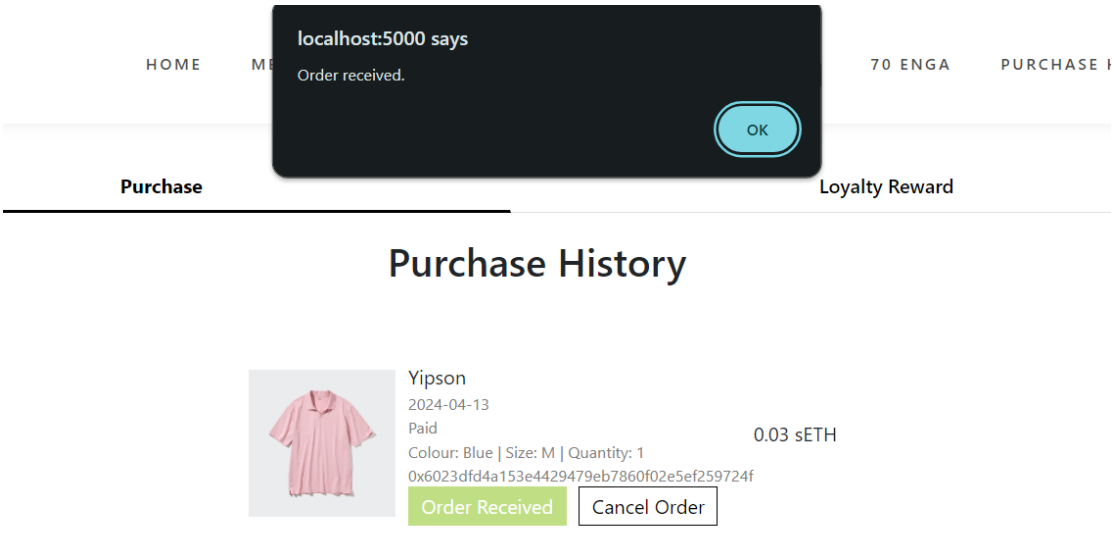


Figure 5.4.31 Confirming Delivery Transaction Completed

When the transaction is processed, an alert dialog will appear, and the page will refresh after the “OK” is clicked.

Figure 5.4.32 Transaction History Page After Confirming Delivery

The status will convert from “Paid” to “Delivered”, and a new button will appear which is “Collect Point”.

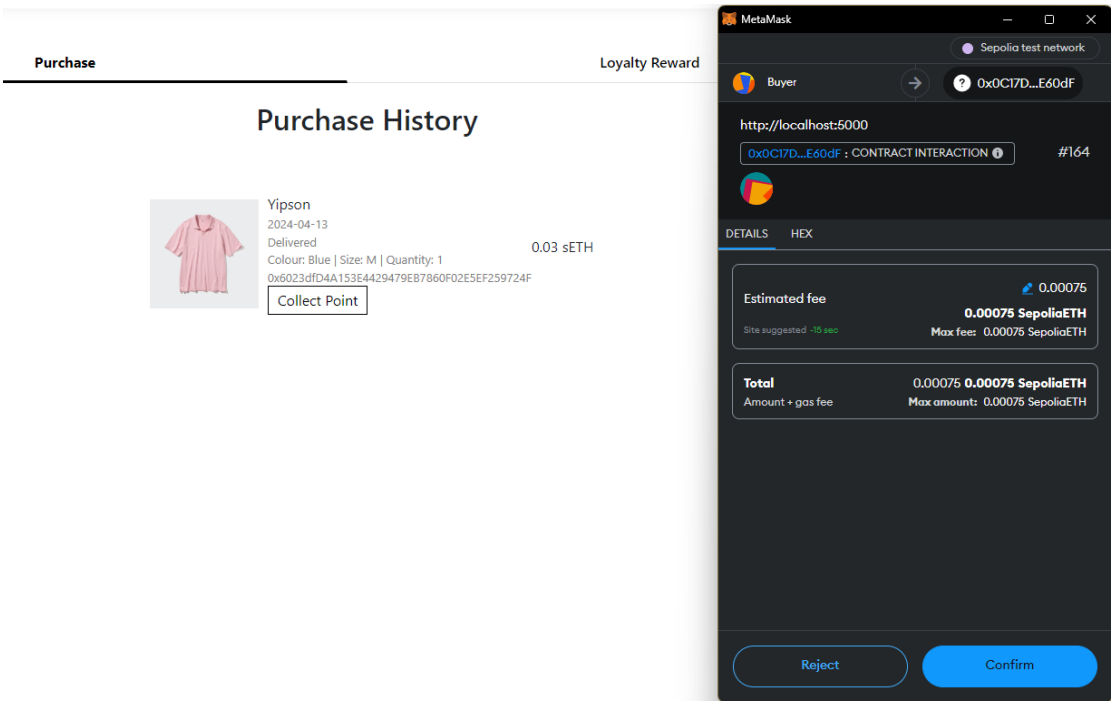


Figure 5.4.33 MetaMask Web Extension Popout for Claiming Loyalty Point

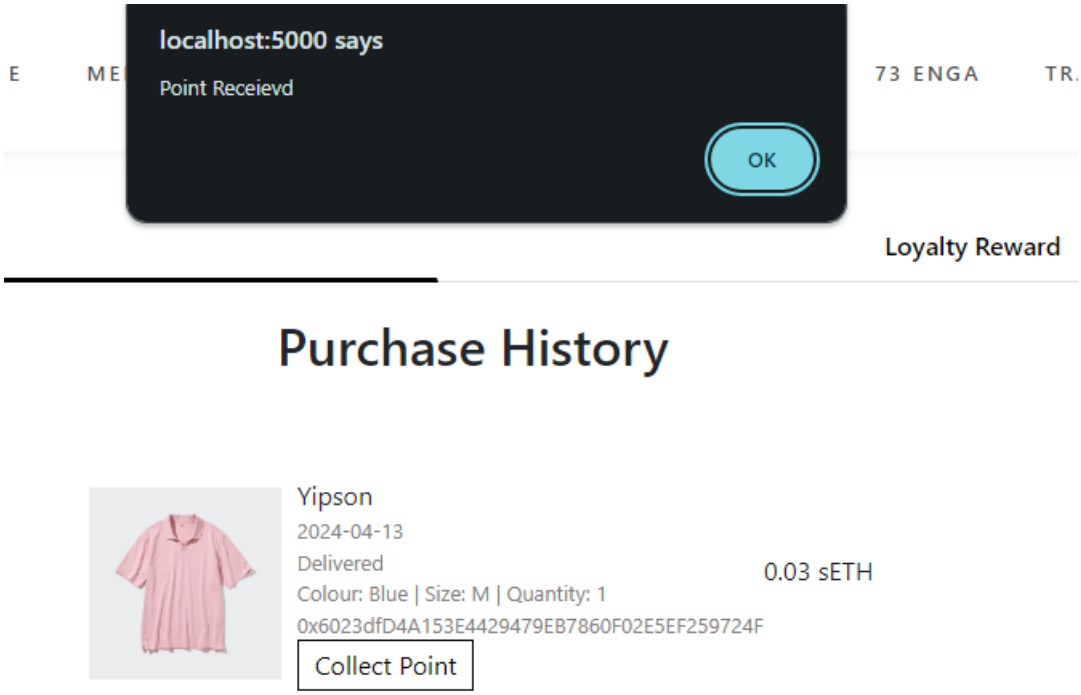


Figure 5.4.34 Claiming Point Transaction Completed

When the transaction is processed, an alert dialog will appear, and the page will refresh after the “OK” is clicked.

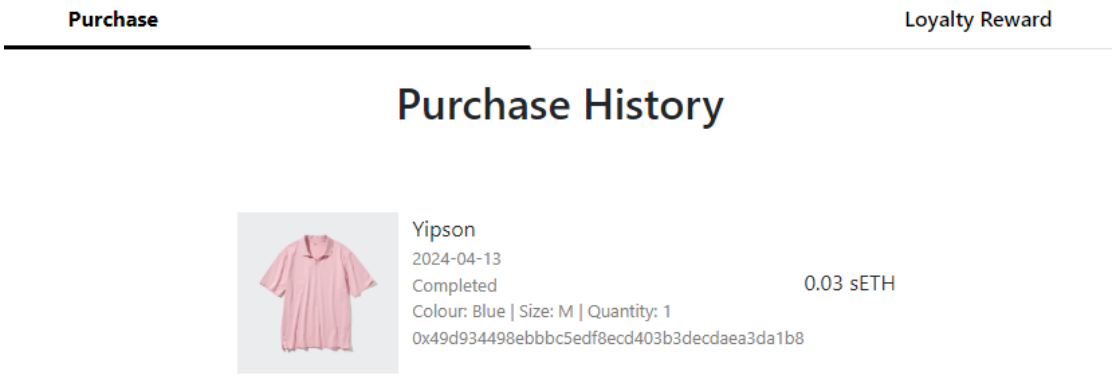


Figure 5.4.35 Transaction History Page After Claiming Point

After the point is claimed, the “Collect Point” button will disappear, and the status will change from “Delivered” to “Completed”.

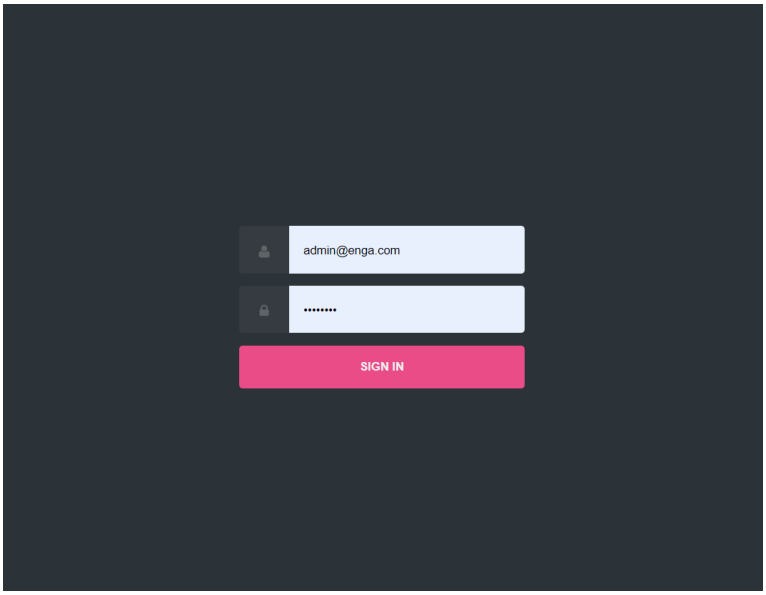


Figure 5.4.36 Admin Login Page

This page is the admin login page, only after logging in, then the user can access the configuration page.

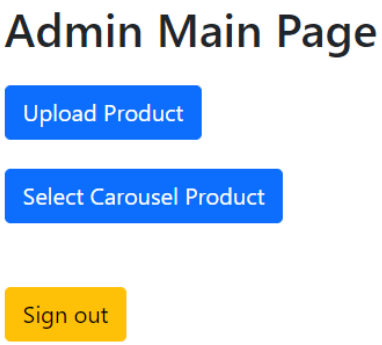


Figure 5.4.37 Admin Configuration Page

After logging in, the user will be redirected to the configuration selection page.

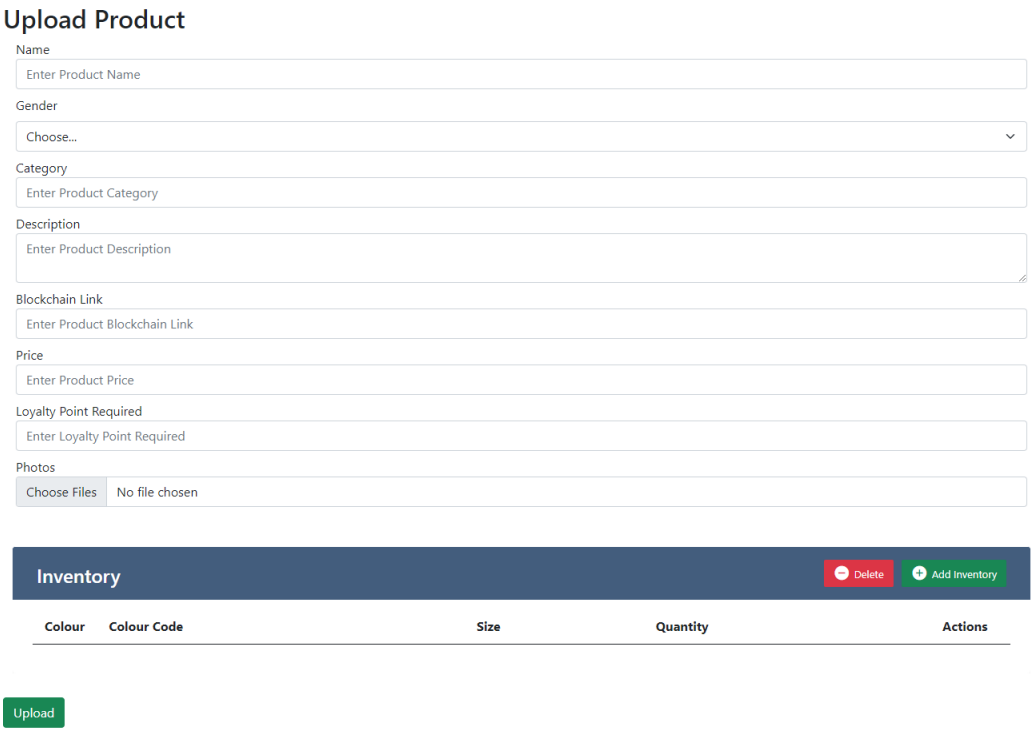


Figure 5.4.38 Upload Product Page

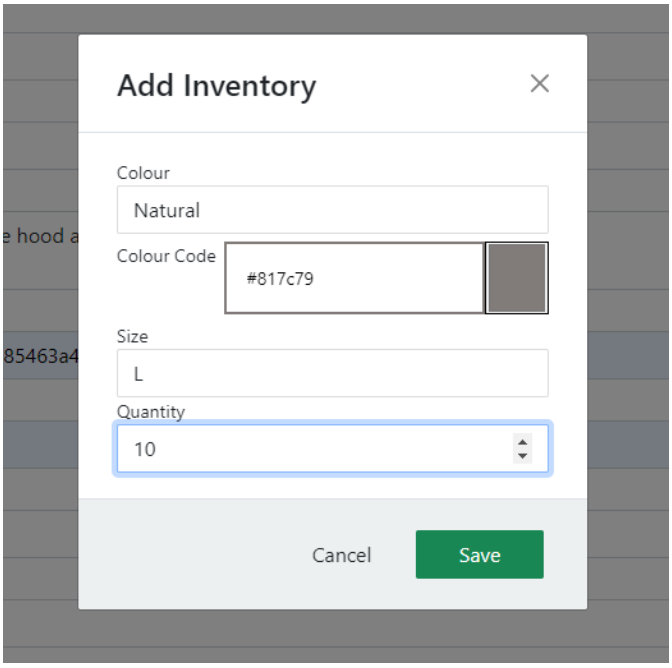


Figure 5.4.39 Modal of Add Inventory

When the user clicks “Add Inventory”, the modal above will pop up.

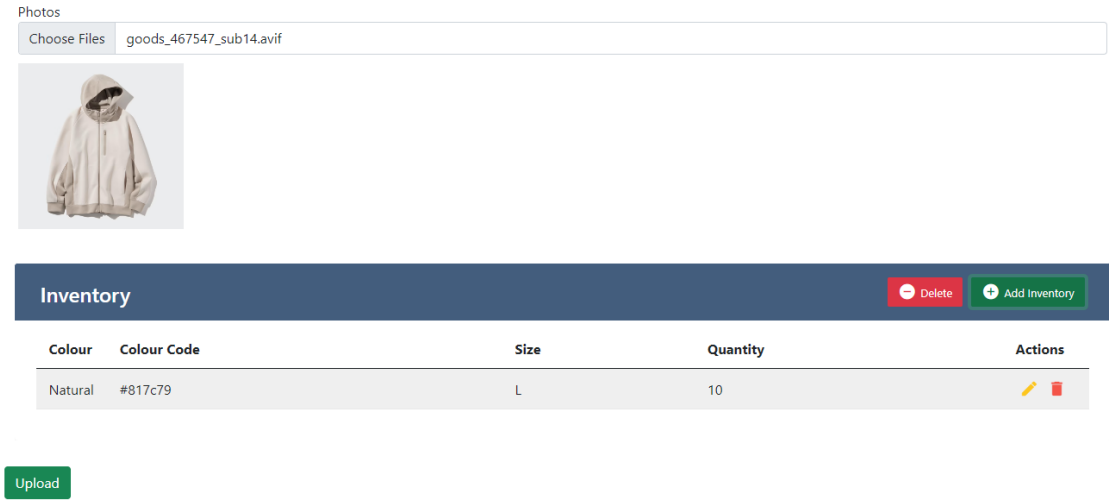


Figure 5.4.40 Inventory Data Added into Inventory Table

After saving the new inventory, the data will appear in the Inventory table.

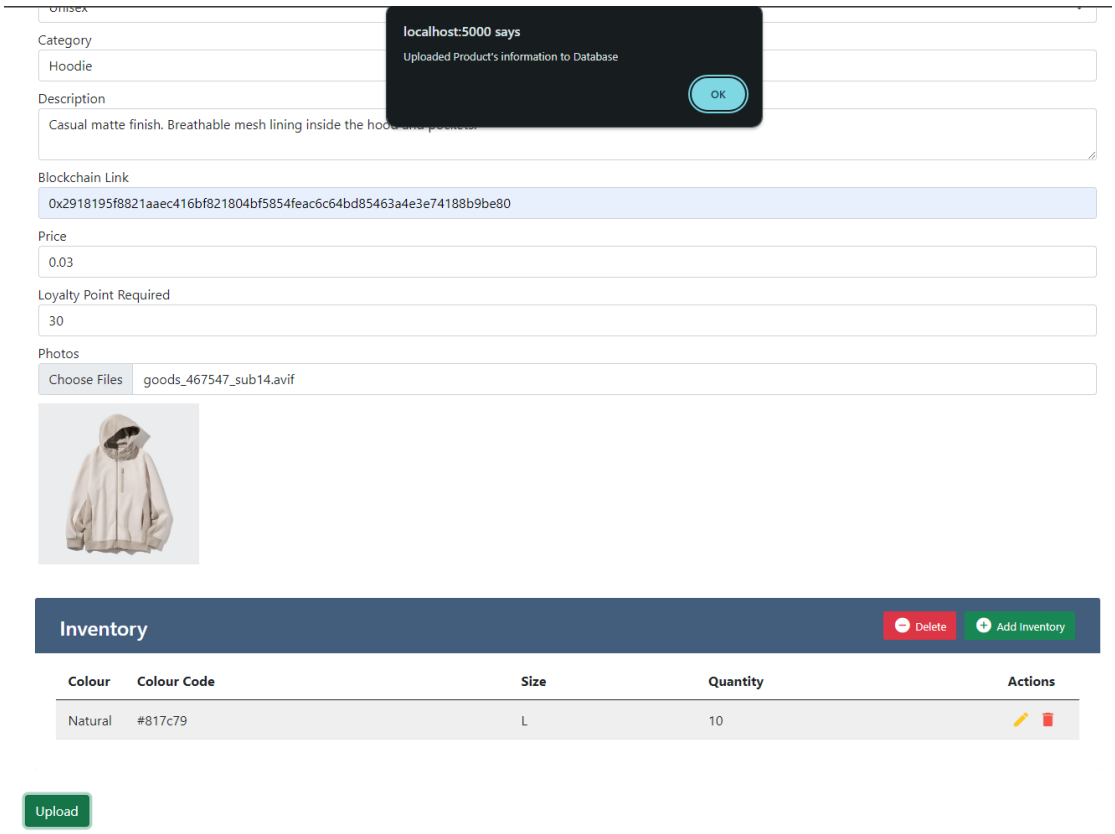


Figure 5.4.41 Product successfully upload into Database

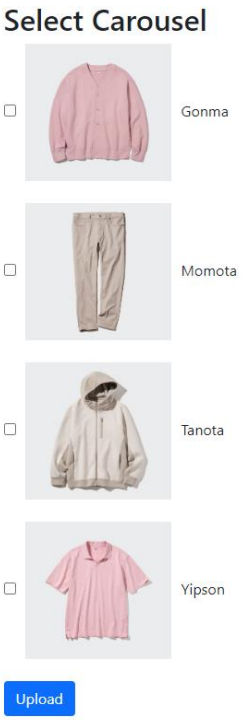


Figure 5.4.42 Product Successfully Uploaded into Database

On the Select Carousel page, all products will be listed, user can select multiple products to display in the homepage's carousel.

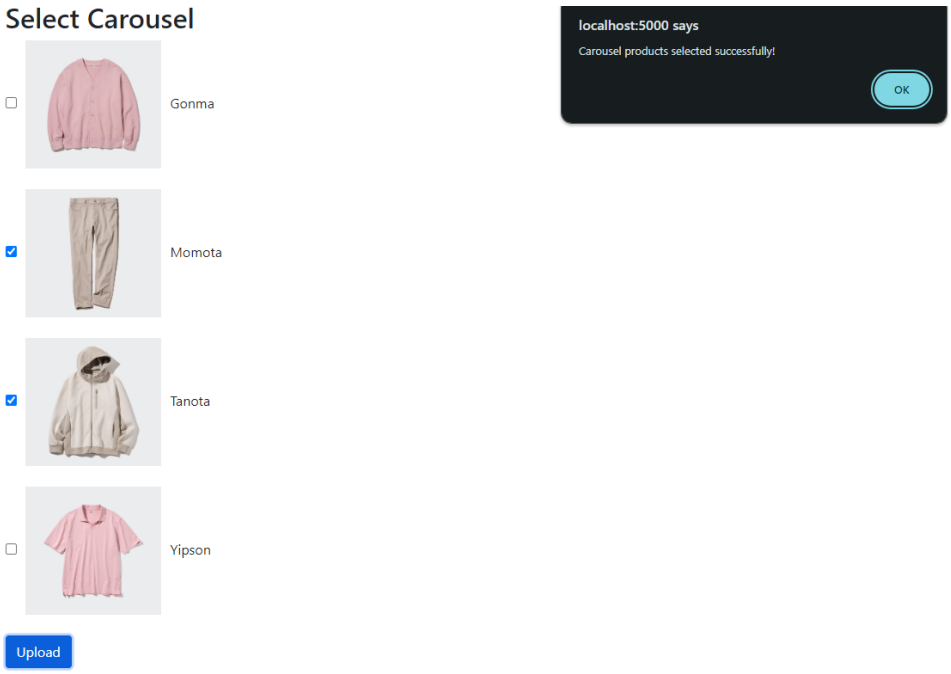


Figure 5.4.43 Carousel Products Updated Successfully

5.5 Timeline

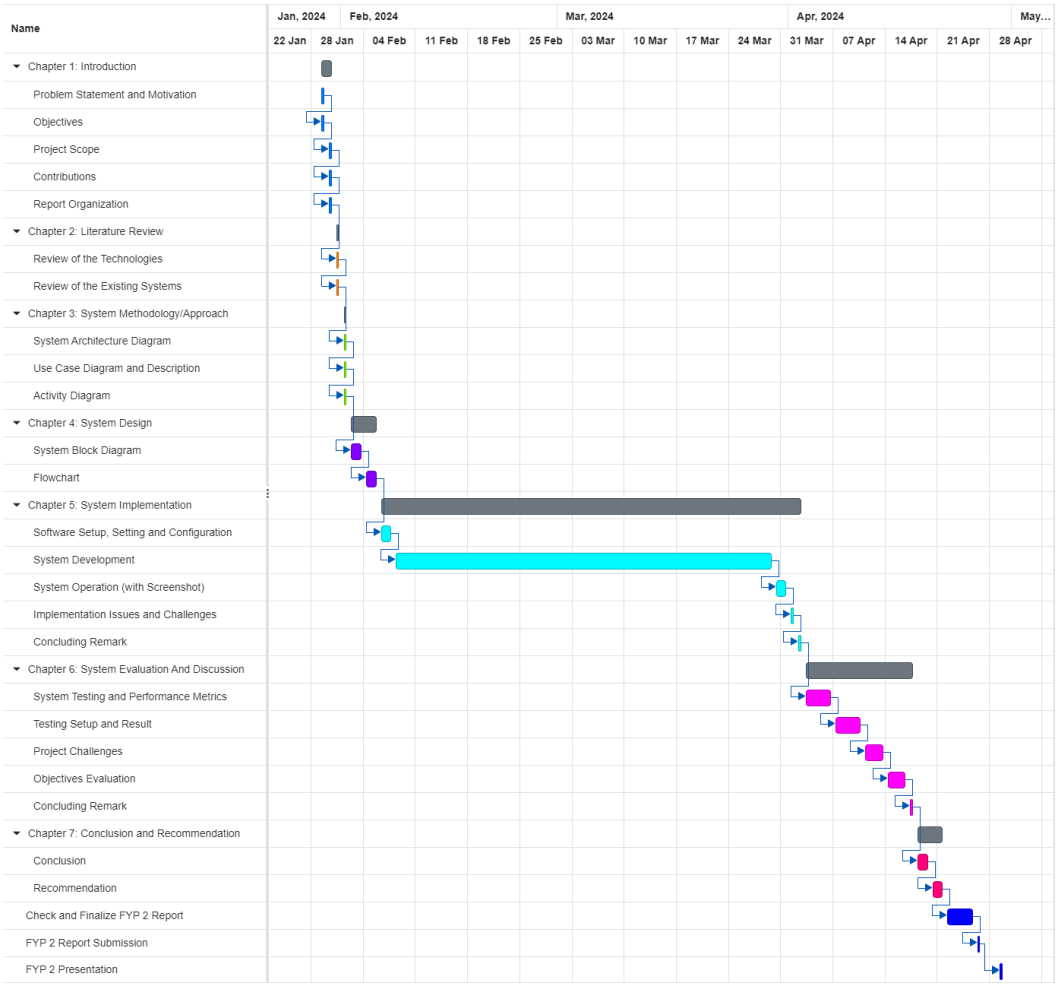


Figure 5.5.1 Gantt Chart for FYP 2

CHAPTER 6: System Evaluation and Discussion

6.1 Testing Setup and Result

Unit Testing 1: Login using MetaMask

Input	Expected Output	Actual Output
Users connect their MetaMask to the system	The system able to retrieve the user's wallet address and loyalty point balance and display it in the navigation bar	The system retrieved the user's wallet address and loyalty point balance and displayed it in the navigation bar

Table 6.1.1 Unit Testing 1

Figure 6.1.1 After Login using MetaMask

Unit Testing 2: Deploy Purchase Escrow Contract

Input	Expected Output	Actual Output
Users connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
Users signed the requested transaction	The transaction will be posted on the Sepolia Testnet	The transaction has been posted on the Sepolia Testnet
User clicked "Deploy Purchase Escrow Contract", but insufficient funds to pay the gas fee	MetaMask will not allow the user to sign the transaction	MetaMask did not allow the user to sign the transaction
User clicks the "Purchase" button, and	The system will proceed to the payment progress instead of	The system proceeded to the payment progress

there's an unused escrow contract	deploying escrow	
The transaction is completed	The system will change "Deploy Purchase Escrow Contract" to "Make Payment"	The system changed "Deploy Purchase Escrow Contract" to "Make Payment"

Table 6.1.2 Unit Testing 2

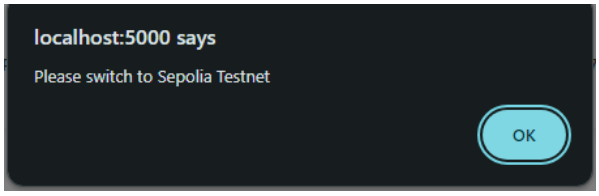


Figure 6.1.2 Alert Dialog of Switching Network

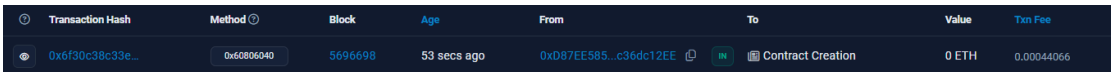


Figure 6.1.3 Deployment of Contract Successful

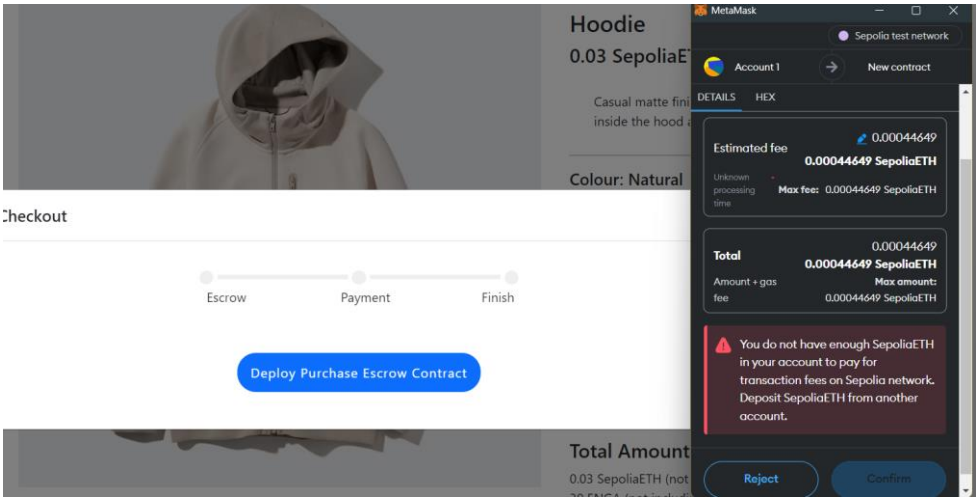


Figure 6.1.4 Insufficient Balance

Unit Testing 3: Make Purchase Payment

Input	Expected Output	Actual Output
User connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
User clicks "Make Payment", but insufficient balance	The system will pop out an alert dialog that reminds the user had balance insufficient	The system popped out an alert dialog that reminded the user balance insufficient
User signed the requested transaction	The transaction will be posted on the Sepolia Testnet, the payment amount will be deducted from the user account and transferred to the escrow contract address	The transaction has been posted on the Sepolia Testnet, the payment amount was deducted from the user account and transferred to the escrow contract address
The transaction is completed	The system will remove "Make Payment", display "Payment Successful", progress will proceed to "Finish", reload the page after clicking on the alert dialog, and the transaction will added to the transaction history with a "Paid" status	The system removed "Make Payment", displayed "Payment Successful" progress proceeded to "Finish", the page reloaded after clicking on the alert dialog", and the transaction was added to the transaction history with a "Paid" status

Table 6.1.3 Unit Testing 3

Figure 6.1.5 Payment Transferred to Contract

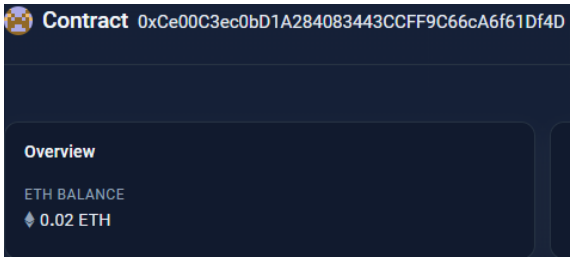


Figure 6.1.6 Balance of Contract

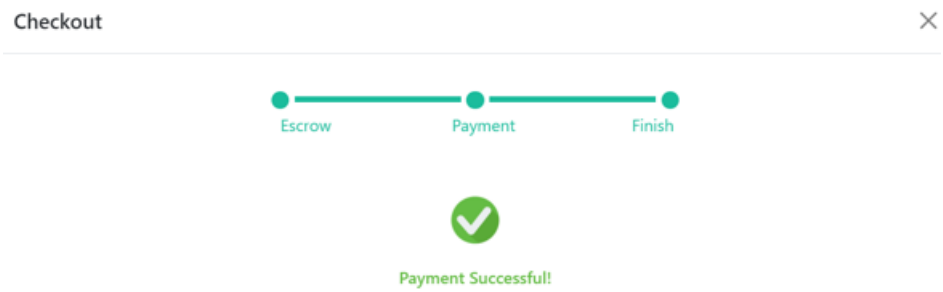


Figure 6.1.7 Modal of Successful Payment

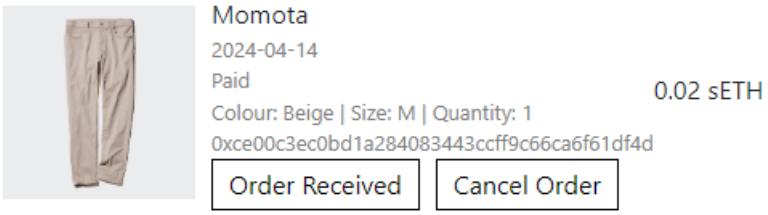


Figure 6.1.8 Product in Transaction History Page After Payment Made

Unit Testing 4: Return Purchase Payment

Input	Expected Output	Actual Output
Users connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
User clicked "Cancel Order", but insufficient funds to pay the gas fee	MetaMask will not allow the user to sign the transaction	MetaMask did not allow the user to sign the transaction
User signed the requested transaction	The transaction will be posted on the Sepolia Testnet, the payment amount will be released back from the escrow contract address to the user account	In the transaction posted on the Sepolia Testnet, the payment amount was released back from the escrow contract address to the user account

Table 6.1.3 Unit Testing 4

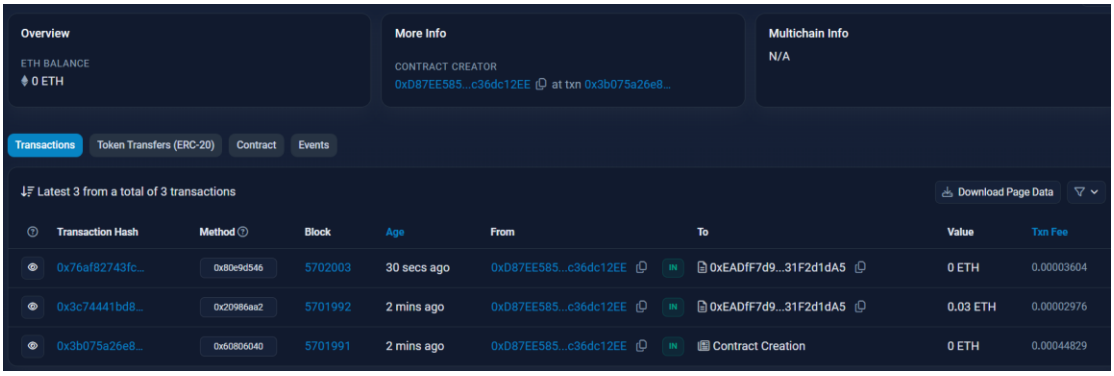


Figure 6.1.9 Payment Return Transaction Page on Etherscan Blockchain Explorer

Unit Testing 5: Confirm Purchase Delivery

Input	Expected Output	Actual Output
User connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
User clicked "Order Received", but insufficient funds to pay the gas fee	MetaMask will not allow the user to sign the transaction	MetaMask did not allow the user to sign the transaction
User signed the requested transaction	The transaction will be posted on the Sepolia Testnet, the payment amount will be released to the seller account from the escrow contract, the status will turn to "Delivered", and the "Collect Point" button will appear under the transaction in "Purchase History" page	The transaction was posted on the Sepolia Testnet, the payment amount was released to the seller account from the escrow contract, the status turned to "Delivered", and the "Collect Point" button appeared under the transaction in the "Purchase History" page

Table 6.1.5 Unit Testing 5

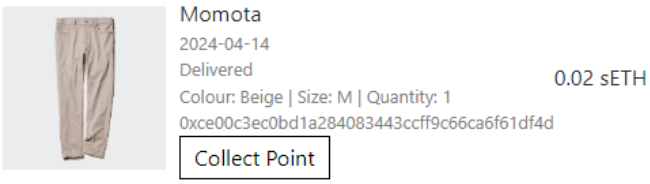


Figure 6.1.10 Product in Transaction History Page After Confirming Order Received

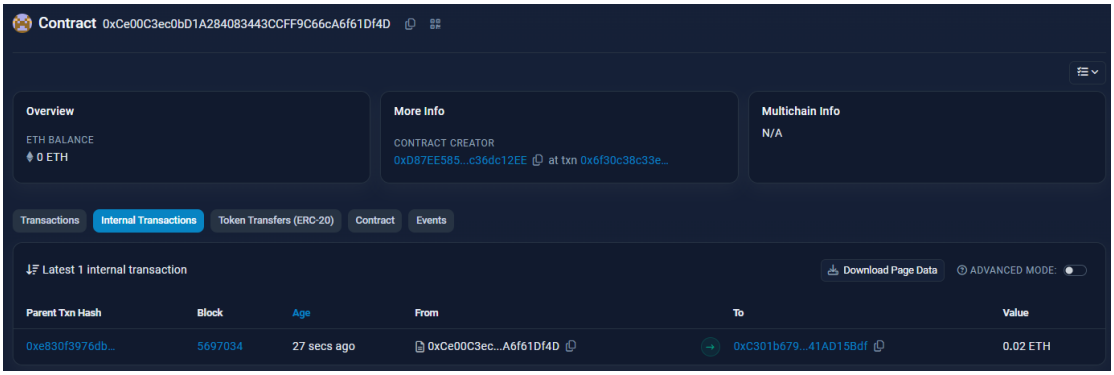


Figure 6.1.11 Releasing Payment to Seller Transaction Page on Etherscan Blockchain Explorer

Unit Testing 6: Claim Loyalty Point

Input	Expected Output	Actual Output
Users connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
User clicked "Claim Point", but insufficient funds to pay the gas fee	MetaMask will not allow the user to sign the transaction	MetaMask did not allow the user to sign the transaction
Users signed the requested transaction	The transaction will be posted on the Sepolia Testnet, the smart contract that holding the loyalty point will release the loyalty point to the user, and the transaction status will become "completed"	The transaction posted on the Sepolia Testnet, the smart contract that holding the loyalty point released the loyalty point to the user, and the transaction status became "completed"

Table 6.1.6 Unit Testing 6

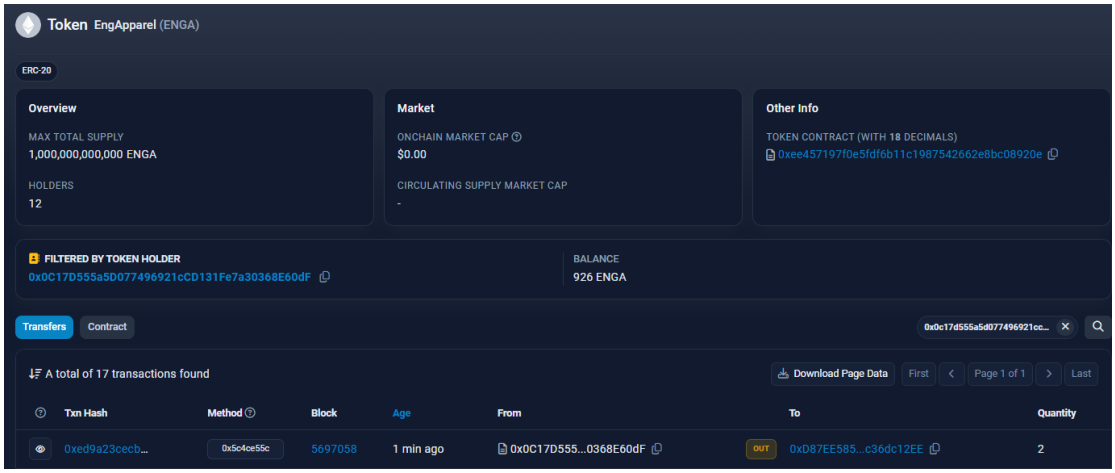


Figure 6.1.12 Claiming Point Transaction Page on Etherscan Blockchain Explorer

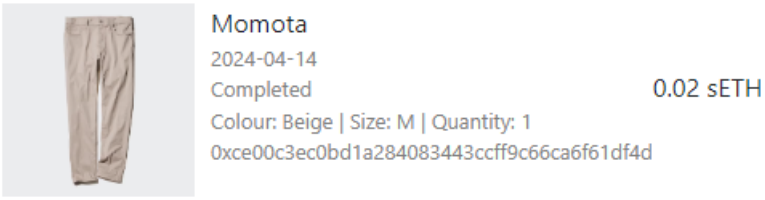


Figure 6.1.13 Product in Transaction History Page After Claiming Point

Unit Testing 7: Deploy Loyalty Reward Escrow Contract

Input	Expected Output	Actual Output
Users connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
Users signed the requested transaction	The transaction will be posted on the Sepolia Testnet, and it will create a transaction with the status "Created"	The transaction has been posted on the Sepolia Testnet, it created a transaction with the status "Created"
User clicks the "Redeem" button	The system will pop out a modal that include two selections, "Redeem with Points", and "Redeem with NFTs"	The system popped out a modal that include two selections, "Redeem with Points", and "Redeem with NFTs"
User clicks the "Redeem with Points" or "Redeem with NFTs" button and there's an unused escrow contract	The system will proceed to the payment progress instead of deploying escrow	The system proceeded to the payment progress
User clicked "Deploy Loyalty Point Escrow" or "Deploy NFT Escrow", but insufficient funds to pay the gas fee	MetaMask will not allow the user to sign the transaction	MetaMask did not allow the user to sign the transaction
The transaction is completed	The system will change "Deploy Loyalty Point Escrow" to "Deposit Loyalty Point" or "Deploy NFT Escrow" to Deposit NFT"	The system changed "Deploy Loyalty Point Escrow" to "Deposit Loyalty Point" or "Deploy NFT Escrow" to Deposit NFT"

Table 6.1.7 Unit Testing 7

Unit Testing 8: Make Loyalty Reward Payment

Input	Expected Output	Actual Output
Users connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
Users click "Deposit Loyalty Point" or "Deposit NFT", but insufficient balance	The system will pop out an alert dialog that remind user balance insufficient	The system popped out an alert dialog that remind user balance insufficient
User clicked "Deposit Loyalty Point" or "Deposit NFT", but had insufficient funds to pay the gas fee	MetaMask will not allow the user to sign the transaction	MetaMask did not allow the user to sign the transaction
User signed the requested transaction	The transaction will be posted on the Sepolia Testnet, the payment amount will be deducted from the user account and transferred to the escrow contract address	The transaction has been posted on the Sepolia Testnet, the payment amount was deducted from the user account and transferred to the escrow contract address
The transaction is completed	The system will remove "Deposit Loyalty Point" or "Deposit NFT", display "Payment Successful", progress will proceed to "Finish", reload the page after clicking on the alert dialog, and the transaction will add to the transaction history with a "Paid" status	The system removed "Deposit Loyalty Point" or "Deposit NFT", displayed "Payment Successful" progress proceeded to "Finish", the page reloaded after clicking on the alert dialog", and the transaction was added to the transaction history with a "Paid" status

Table 6.1.8 Unit Testing 8

Unit Testing 9: Return Loyalty Reward Payment

Input	Expected Output	Actual Output
Users connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
User clicked "Cancel Order", but insufficient funds to pay the gas fee	MetaMask will not allow the user to sign the transaction	MetaMask did not allow the user to sign the transaction
Users signed the requested transaction	The transaction will be posted on the Sepolia Testnet, the payment amount or deposited NFT will be released back from the escrow contract address to the user account	In the transaction posted on the Sepolia Testnet, the payment amount or deposited NFT was released back from the escrow contract address to the user account

Table 6.1.9 Unit Testing 9

Unit Testing 10: Confirm Loyalty Reward Delivery

Input	Expected Output	Actual Output
Users connected to another network instead of Sepolia Testnet	The system will pop out an alert dialog that reminds the user to change the network to Sepolia	The system popped out an alert dialog that reminded the user to change the network to Sepolia
User clicked "Order Received", but insufficient funds to pay the gas fee	MetaMask will not allow the user to sign the transaction	MetaMask did not allow the user to sign the transaction
Users signed the requested transaction	The transaction will be posted on the Sepolia Testnet, the payment amount will be released to the seller account from the escrow contract, and	The transaction posted on the Sepolia Testnet, the payment amount was released to the seller account from the escrow contract,

	the status will turn to "Completed"	and the status turned to "Completed"

Table 6.1.10 Unit Testing 10

Unit Testing 11: Admin Login

Input	Expected Output	Actual Output
User entered the correct email and password	The system will redirect the user to the Admin configuration page	The system redirected the user to the Admin configuration page
User entered the wrong email and password	The system will pop out an alert dialog that reminds the user username or password is wrong	The system will pop out an alert dialog that reminds the user username or password is wrong

Table 6.11 Unit Testing 11

Unit Testing 12: Upload Product

Input	Expected Output	Actual Output
User submits product information	The system will upload the product information to Firebase	The system uploaded the product information to Firebase
User submitted the product information but didn't fill in all the fields	The system will pop out an alert dialog that reminds the user to fill in all fields	The system popped out an alert dialog that reminded the user to fill in all fields

Table 6.1.12 Unit Testing 12

Unit Testing 13: Select Carousel Product

Input	Expected Output	Actual Output
User submits the selected product	The system will upload the selected product to Firebase	The system uploaded the selected product to Firebase
After submitting the	The system will display the	The system displayed the

selected products, user enters the homepage	selected products in the carousel	selected products in the carousel

Table 6.1.13 Unit Testing 13

Unit Testing 14: Product Page

Input	Expected Output	Actual Output
User enters the selected product page	The system will pull the product information from Firebase to the page and display it according to the layout.	The system pulled the product information from Firebase to the page and displayed it according to the layout.
User scanned the QR code or visited the link in the description section	The system will redirect the user to the transaction's Blockchain Explorer page	The system redirected the user to the transaction's Blockchain Explorer page

Table 6.1.14 Unit Testing 14

Unit Testing 15: Product List Page

Input	Expected Output	Actual Output
User enters the product list page	The system will pull all products from Firebase to the page and display it according to the layout.	The system pulled all products from Firebase to the page and display it according to the layout.
User check or uncheck the category or gender filter	The system will only display the checked filter category and gender product	The system only displayed the checked filter category and gender product
User clicked on the product card	The system will redirect user to the selected product page	The system redirected user to the selected product page

Table 6.1.15 Unit Testing 15

6.2 Project Challenges

During the implementation phase, I faced plenty of issues and challenges in my proposed Blockchain-based project. Although Blockchain technology was created in the year 2008 by Satoshi Nakamoto, which is 15 years ago, it wasn't talked about until a few years ago. In my opinion, Blockchain technology is still too immature to be applied to various fields in recent years when compared to the traditional method. The research material on this topic is still scarce, but I believe that this technology will be put in an important position in the future due to its decentralization characteristic. Due to the limited study material is limited, it took me, a person who very newbie to Blockchain, a long time to get a bit familiar with this technology. Despite it costs me a lot of time to get some functions done, it makes me feel happier when I achieve something difficult for me.

On the technical part, there are some challenges I have encountered. One of the challenges will be writing smart contracts written in Solidity Language. It is the first time I have coded with this language, which is kind of challenging for me. For example, when I was writing the contract for the Purchase and Loyalty Reward Escrow Contract, the functions execution kept reverted, and it took me a long time to make those functions work properly. Another challenge will be the system layout. Due to my front-end programming skills is not solid enough, I have spent a lot of time designing the website layout in HTML and CSS such as the carousel and product page. One of them is the gas fee. Due to the gas fee fluctuating in response to supply and demand, it will rocket high during peak transaction times, as there are more transactions to validate by the miners. When there is a transaction requested at the peak time, it will be disapproved automatically due to the gas limit I have set in the coding part, especially for the part where the loyalty point token and NFT will automatically transfer to the customer when the funds are released to the seller. This causes transactions can’t be made at any time anywhere. The solution on this part is to raise the ceiling and bear with a higher gas fee.

6.3 Objectives Evaluation

To overcome the problem statement that I have mentioned in Chapter 1, four objectives have been established, which include resolving apparel CLP users' data privacy and security issues, enhancing the payment security measures by intervention of third-party, providing another form of obtaining and spending loyalty points, and increase the comprehensive transparency of the apparel lifecycle. In this section, I will evaluate how well I have achieved those objectives.

For the first objective which regards data privacy and security issues, the system can let users log in using a decentralized way, which is by a cryptocurrency wallet instead of a centralized way such as using Google, so it can reduce the risk of a single point of failure or data breach. The second objective, the payment security, the system can let users purchase or redeem items with a decentralized escrow party, which is made by smart contracts. Due to it having no human intervention, the process is all programmed with conditions. The third objective is about the loyalty point. The system will enable users to claim their cryptocurrency according to the amount they have paid for the product, which is the loyalty point, ENGA after they have received the product. It can increase the flexibility and expandability of loyalty points. The last objective will be the comprehensive transparency of the apparel lifecycle. The system now will attach a link and a QR code to the product page which is linked to the transaction page of the product in the Etherscan Blockchain Explorer.

CHAPTER 7: Conclusion and Recommendation

7.1 Conclusion

In the apparel industry, building and maintaining customer loyalty is essential due to fierce competition and changing trends. Traditional Customer Loyalty Programs (CLPs) face several challenges. Firstly, there are concerns about data privacy and security, as customer data is centralized and not under the control of users. This vulnerability has led to a significant number of data breaches, undeniable Malaysia ranks high in data leak incidents. Secondly, payment security is a severe issue, as upfront payments to sellers' bank accounts can result in fraud and cause a loss of trust and customer loyalty. Additionally, inflexible loyalty points systems contribute to users losing interest in CLPs. Lastly, there's a growing demand for sustainability in the apparel industry due to consumers nowadays prefer transparent information about materials and sourcing.

The proposed project is to create a web application-based apparel CLP using Blockchain technology. The project aims to provide a decentralized shopping environment for customers in the apparel industry. By decentralizing it, users will be able to fully control their privacy because, in the Blockchain network, everyone is anonymous, meanwhile, it also removes the trust problem between sellers and buyers. The existing system in Malaysia's apparel industry is vulnerable to cyberattacks. Due to the traditional method is using centralized networks, when there is a single point of failure or data breach, all users will encounter it. By implementing Blockchain, the risk of a single point of failure or data breach will be reduced remarkably due to its decentralized nature.

This system allows customers to purchase items that are uploaded by the sellers using their MetaMask wallet and those purchase transactions will be stored on the Blockchain transparently and anonymously. Besides purchasing, customers can use the loyalty point, which is cryptocurrency stored inside their wallet to redeem the items listed. The purchase and redemption process will be intervened by an escrow service, which is a smart contract written in Solidity language. Only when customers receive their product, then the payment will be released to the seller. Also, customers can choose to cancel an order and the payment will be transferred back to them. For

the seller user side, they can choose to upload a product and select the carousel's product for the homepage's carousel. Every transaction made through the Blockchain network requires users to pay the gas fee for the network nodes on validating transactions via PoS, which is usually in the range of RM10.

The existing CLPs that I have reviewed include Whimsigirl, TNTCO, ANAABU, and Pestle & Mortar Clothing. Up to now, all the reviewed systems are using a centralized way of dealing with their customer's data. Compared to these existing CLPs, the proposed system helps to reduce the overall risk and provides user greater control over their data.

For the methodology, Test Driven Development (TDD) is deemed the most suitable software development methodology for the proposed system, aligning with Agile principles due to its iterative nature. As a solo project, TDD aids in defining specific test cases before coding, ensuring a clear understanding of requirements and expected behavior. The TDD process comprises three phases: Red, where failing tests are created to inform feature implementation; Green, where the minimum code is written to pass tests; and Refactor, focusing on code optimization without altering functionality. This cycle repeats for each new functionality, fostering continuous improvement and adherence to requirements.

During the implementation phase of my Blockchain-based project, I encountered numerous challenges stemming from the technology's relative immaturity and my limited familiarity with it. Despite Blockchain's inception over a decade ago, it only gained significant attention in recent years, making comprehensive research material scarce. Nonetheless, I believe Blockchain's decentralized nature will position it prominently in the future. Technically, writing smart contracts in Solidity posed a significant challenge, as it was my first time working with the language. Additionally, designing the system layout using HTML and CSS proved time-consuming due to my limited front-end skills. Gas fees presented another hurdle, especially during peak transaction times, leading to disapproved transactions. Ultimately, overcoming these challenges brought a sense of achievement, despite the considerable time investment required.

In a nutshell, this proposed project can provide quite a few advantages for users no matter sellers or the buyer. I believe that the decentralization concept or Blockchain can further implemented in more industries to provide users with more control over their data.

7.2 Recommendation

Although the system has the main functions that make the system indeed workable in the real world for retailing, still there are some features and functions that can be added to improve the system.

First, the configuration for the seller side can have more options such as a return policy, privacy policy, and more information about the brand so that customers will know more about the brand and know what to do when they face some cases. By enabling that information, the system can be generalized in the industry, whoever needs a Blockchain-based web application to build their business, can just fill in their information such as their wallet address for receiving funds, edit the web application information such as return policy, and they are good to host the web application.

Furthermore, for the buyer side, features such as add to cart, reviewing products, stylish recommendations, and browsing the web application on mobile devices can be added to the system. Adding these features can enhance user experience and confidence in products and brands. After adding product reviewing and stylish recommendations to the system, it will become a small social network for those who are finding recommendations for their dress collocation. Moreover, enabling users to browse through their mobile devices, helps to increase traffic of the system because nowadays people will bring their mobile devices along with them all day but not always their laptop or PC devices.

REFERENCES

[1] Kaspersky, "How Data Breaches Happen," *Kaspersky*, 2022. https://www.kaspersky.com/resource-center/definitions/data-breach (accessed Sep. 06, 2023).

[2] N. N. A. Halimy, "Malaysia comes in at the 11th spot for breach of user's data," *Sinar Daily*, Feb. 20, 2023. https://www.sinardaily.my/article/190554/malaysia/national/malaysia-comes-in-at-the-11th-spot-for-breach-of-users-data (accessed Sep. 06, 2023).

[3] K. Haqeem, "Recurring Data Breaches in Malaysia - Plain Ignorance or Just Weak Enforcement," *Cyber Security Asean*, Mar. 21, 2023. https://cybersecurityasean.com/daily-news/recurring-data-breaches-malaysia-plain-ignorance-or-just-weak-enforcement (accessed Sep. 06, 2023).

[4] Y. Y. A. Talib, "The Current State of Social Commerce Fraud in Malaysia and the Mitigation Strategies," *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 9, no. 2, pp. 1593–1599, Apr. 2020, doi: https://doi.org/10.30534/ijatcse/2020/105922020. (accessed Sep. 06, 2023).

[5] K. Perimbanayagam, "Malaysians lost RM58 mil to online shopping scammers this year | New Straits Times," *NST Online*, Nov. 08, 2021. https://www.nst.com.my/news/nation/2021/11/743575/malaysians-lost-rm58-mil-online-shopping-scammers-year (accessed Sep. 06, 2023).

[6] "Who is to blame for online fraud?," *www.thesundaily.my*, Jun. 09, 2023. https://www.thesundaily.my/local/who-is-to-blame-for-online-fraud-FI11081545 (accessed Sep. 06, 2023).

[7] "There's a reason why customers ignore or leave your loyalty program," *Power2motivate.com*, 2017. https://www.power2motivate.com/news-blog/blog/why-customers-ignore-or-leave-your-loyalty-program (accessed Sep. 06, 2023).

[8] T. Garai, "How to Prevent Customers From Sitting on Their Loyalty Points," *antavo.com*, Jun. 01, 2023. https://antavo.com/blog/loyalty-points/ (accessed Sep. 06, 2023).

[9] A. Granskog, L. Lee, K.-H. Magnus, and C. Sawers, "Survey: Consumer Sentiment on Sustainability in Fashion," *McKinsey & Company*, Jul. 17, 2020. https://www.mckinsey.com/industries/retail/our-insights/survey-consumer-sentiment-on-sustainability-in-fashion (accessed Sep. 06, 2023).

[10] Circularity, "Why should every fashion and lifestyle brand consider recommerce?," *Bleckmann.com*, May 16, 2023. https://www.bleckmann.com/resources/why-should-every-fashion-lifestyle-brand-consider-recommerce (accessed Sep. 06, 2023).

[11] E. Chan, "We Still Don't Have Enough Transparency In Fashion," *British Vogue*, Jul. 14, 2022. https://www.vogue.co.uk/fashion/article/fashion-transparency-index-2022 (accessed Sep. 06, 2023).

[12] C. Haynes, "What is Customer Retention, Importance, Examples & Techniques," *The Daily Egg*, Mar. 21, 2019. https://www.crazyegg.com/blog/customer-retention/ (accessed Sep. 06, 2023).

[13] A. C. W. Fook and O. Dastane, "Effectiveness of Loyalty Programs in Customer Retention: A Multiple Mediation Analysis," *Jindal Journal of Business Research*, vol. 10, no. 1, pp. 7–32, Apr. 2021, doi: https://doi.org/10.1177/22786821211000182. (accessed Sep. 06, 2023).

[14] S. Ogino, “The 10 Most Important Pros and Cons of Loyalty Programs,” *Annexcloud.com*, Mar. 13, 2019. https://www.annexcloud.com/blog/10-pros-and-cons-of-loyalty-programs/ (accessed Sep. 06, 2023).

[15] PYMNTS, “Starbucks Loyalty Members Drive 53% of US Revenue,” *www.pymnts.com*, Aug. 02, 2022. https://www.pymnts.com/earnings/2022/starbucks-invests-new-rewards-loyalty-members-help-inflation-proof-brand/ (accessed Sep. 06, 2023).

[16] T. Joshi, “Features of Blockchain,” *GeeksforGeeks*, Feb. 05, 2020. https://www.geeksforgeeks.org/features-of-blockchain/ (accessed Sep. 06, 2023).

[17] A. Ujjawal, “How Does the Blockchain Work?,” *GeeksforGeeks*, Aug. 14, 2018. https://www.geeksforgeeks.org/how-does-the-blockchain-work/ (accessed Sep. 06, 2023).

[18] Synopsys, “What Is Blockchain and How Does It Work? | Synopsys,” *www.synopsys.com*, 2022. https://www.synopsys.com/glossary/what-is-blockchain.html (accessed Sep. 06, 2023).

[19] J. Frankenfield, “51% Attack,” *Investopedia*, May 06, 2019. https://www.investopedia.com/terms/1/51-attack.asp (accessed Sep. 06, 2023).

[20] K. Gülen, “What Is The Best Blockchain For Smart Contracts And Why? - Dataconomy,” *Data Conomy*, Mar. 01, 2023. https://dataconomy.com/2023/03/01/what-is-the-best-blockchain-for-smart-contracts-and-why/ (accessed Sep. 06, 2023).

[21] S. M. Nzuva, “Smart Contracts Implementation, Applications, Benefits, and Limitations,” *Journal of Information Engineering and Applications*, vol. 9, no. 5, Sep. 2019, doi: https://doi.org/10.7176/jiea/9-5-07. (accessed Sep. 06, 2023).

[22] "Top 6 Smart Contract Languages in 2023 | Chainlink," *chain.link*, May 24, 2023. https://chain.link/education-hub/smart-contract-programming-languages (accessed Sep. 06, 2023).

[23] J. Gavande, "Introduction to Solidity," *GeeksforGeeks*, Jul. 17, 2020. https://www.geeksforgeeks.org/introduction-to-solidity/ (accessed Sep. 06, 2023).

[24] Simplilearn, "What Is Solidity Programming in Ethereum | Simplilearn," *Simplilearn.com*, May 26, 2023. https://www.simplilearn.com/tutorials/blockchain-tutorial/what-is-solidity-programming (accessed Sep. 06, 2023).

[25] Remix, "Remix - Ethereum IDE & community," *Remix - Ethereum IDE & community*. https://remix-project.org/ (accessed Sep. 06, 2023).

[26] B. Academy, "What is a Testnet testnet?," *Bit2Me Academy*, Aug. 23, 2018. https://academy.bit2me.com/en/que-es-testnet/ (accessed Sep. 06, 2023).

[27] Alchemy, "What is the Sepolia testnet?," *www.alchemy.com*. https://www.alchemy.com/overviews/sepolia-testnet (accessed Sep. 06, 2023).

[28] "What is Google Firebase? Everything you Need to Know in 2023," *www.lido.app*. https://www.lido.app/firebase/what-is-google-firebase (accessed Sep. 06, 2023).

[29] Cryptopedia, "The MetaMask Extension: What Is MetaMask Used For?," *Gemini*, Dec. 22, 2021. https://www.gemini.com/cryptopedia/what-is-metamask-how-to-use-metamask-extension (accessed Sep. 06, 2023).

[30] G. Weston, "What is Pinata and how it helps to build the future of web3?," *101 Blockchains*, Aug. 04, 2023. https://101blockchains.com/pinata-in-web3/ (accessed Sep. 06, 2023).

[31] A. Knight, “What are HTML, CSS, & Javascript?,” *California Institute of Arts & Technology*, Sep. 15, 2022. https://www.ciat.edu/blog/html-css-javascript/ (accessed Sep. 06, 2023).

[32] T. Sufiyan, “What is Node.js: A Comprehensive Guide,” *Simplilearn.com*, May 16, 2023. https://www.simplilearn.com/tutorials/nodejs-tutorial/what-is-nodejs (accessed Sep. 06, 2023).

[33] “What is Express.js? | Why should use Express.js? | Features of Express.js,” *Besant Technologies*, Jun. 19, 2020. https://www.besanttechnologies.com/what-is-expressjs (accessed Sep. 06, 2023).

[34] J. Hibbard, “A Beginner’s Guide to Pug - SitePoint,” *www.sitepoint.com*, May 16, 2019. https://www.sitepoint.com/a-beginners-guide-to-pug/ (accessed Sep. 06, 2023).

[35] O. Okuwobi, “Learn Web3.js Basics – Ethereum Development for Beginners,” *freeCodeCamp.org*, Nov. 27, 2023. https://www.freecodecamp.org/news/learn-web3js-basics/ (accessed Sep. 06, 2023).

[36] rcavezza, “Learning About Browserify and Babel while Contributing To Open Source,” *iBuildMVPs*, Feb. 10, 2019. https://ibuildmvps.com/blog/learning-about-browserify-and-babel-while-contributing-to-open-source/ (accessed Sep. 06, 2023).

[37] Javatpoint, “Nodemon - Javatpoint,” *www.javatpoint.com*. https://www.javatpoint.com/nodemon (accessed Sep. 06, 2023).

[38] S. Papastefanos, “Using browserify and watchify to improve your client-side-javascript workflow — /var/,” *spapas.github.io*, May 27, 2015.

https://spapas.github.io/2015/05/27/using-browserify-watchify/ (accessed Sep. 06, 2023).

[39] E. Halpern, "What does Alchemy do in Web3?," *Medium*, Feb. 26, 2022. https://elanhalpern.medium.com/what-does-alchemy-do-in-web3-b8c45624fb9c (accessed Sep. 06, 2023).

[40] G. Weston, "An Introduction to Alchemy - A Web3 Development Platform," *101 Blockchains*, Jan. 04, 2023. https://101blockchains.com/alchemy-web3/ (accessed Sep. 06, 2023).

[41] S. Dhananjaya, "Top Loyalty Programs in the Changing Malaysian Loyalty Landscape," *Capillary Blog*, Mar. 29, 2022. https://www.capillarytech.com/blog/capillary/top-malaysian-loyalty-programs-post-pandemic/ (accessed Sep. 06, 2023).

[42] T. Diwan, "Customer loyalty: The key to business profitability," *www.surveysensum.com*, 2020. https://www.surveysensum.com/customer-experience/customer-loyalty/ (accessed Sep. 06, 2023).

[43] L. Peacock, "7 Innovative Customer Loyalty Programs and How To Start (2022)," *Shopify*, Jun. 22, 2022. https://www.shopify.com/my/blog/loyalty-program (accessed Sep. 06, 2023).

[44] "Whimsigirl Rewards Program," *Whimsigirl*. https://whimsigirl.com/pages/whimsigirl_rewards (accessed Sep. 06, 2023).

[45] Team TNTCO, "TNTCO'S 'S.A.T Project' Week 11," *TNTCO Store*, Sep. 12, 2021. https://tntco.co/blogs/s-a-t-project/tntco-s-s-a-t-project-week-11 (accessed Sep. 06, 2023).

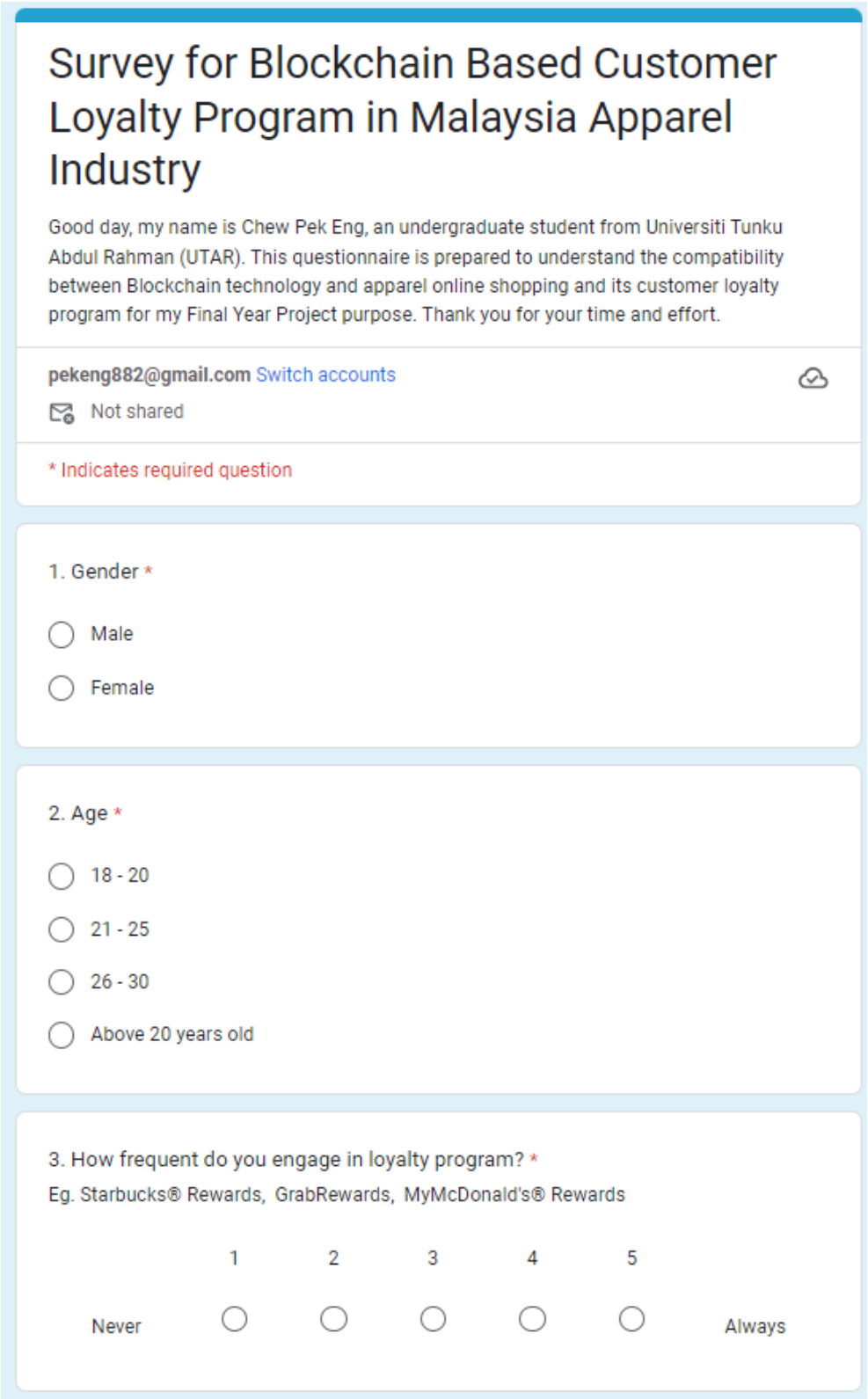
[46] "TNTCO Members Exclusive," *TNTCO Store*. https://tntco.co/collections/tntco-members-exclusive (accessed Sep. 06, 2023).

[47] "ANAABU Rewards," *ANAABU.CO*. https://anaabu.co/pages/anaabu-rewards (accessed Sep. 06, 2023).

[48] "Homie Rewards," *Pestle & Mortar Clothing*. https://pestlemortarclothing.com/pages/homie-points (accessed Sep. 06, 2023).

APPENDIX

System Pre-authoring Google Survey Questions



Survey for Blockchain Based Customer Loyalty Program in Malaysia Apparel Industry

Good day, my name is Chew Pek Eng, an undergraduate student from Universiti Tunku Abdul Rahman (UTAR). This questionnaire is prepared to understand the compatibility between Blockchain technology and apparel online shopping and its customer loyalty program for my Final Year Project purpose. Thank you for your time and effort.

pekeng882@gmail.com Switch accounts

Not shared

* Indicates required question

1. Gender *

- Male
- Female

2. Age *

- 18 - 20
- 21 - 25
- 26 - 30
- Above 20 years old

3. How frequent do you engage in loyalty program? *

Eg. Starbucks® Rewards, GrabRewards, MyMcDonald's® Rewards

	1	2	3	4	5	
Never						Always

4. Indicate your concern about traditional apparel online shop and its customer loyalty program. *

	Strongly Disagree	Disagree	Agree	Strongly Agree
Privacy may be exposed	◯	◯	◯	◯
Payment security not transparent	◯	◯	◯	◯
Lack of flexibility in using loyalty points	◯	◯	◯	◯
Apparel product lifecycle is not transparent	◯	◯	◯	◯

5. Rate your understanding about Blockchain Technology *

Blockchain technology is **a decentralized, distributed ledger that stores the record of ownership of digital assets**. Any data stored on blockchain is unable to be modified, making the technology a legitimate disruptor for industries like payments, cybersecurity and healthcare.

	1	2	3	4	5	
No understanding	◯	◯	◯	◯	◯	Good understanding

6. Do you think that decentralization helps customer loyalty program? *

◯ Yes

◯ No

7. Do you feel more secure when payment is made through Smart Contract instead of human? *

Smart contracts are **scripts that automate the actions between two parties.**

- ◯ Yes
- ◯ No

8. If loyalty point is not just tied to a single platform, but can be use in another cooperative platform, will it increase your usage on the loyalty program? *

- ◯ Yes
- ◯ No

9. If Blockchain technology is applied in apparel industry, how much is your willingness to give it a try? *

	1	2	3	4	5	
Very Unwilling	◯	◯	◯	◯	◯	Very Willing

WEEKLY REPORT

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 2
Student Name & ID: Chew Pek Eng & 20ACB01940	
Supervisor: Dr. Gan Ming Lee	
Project Title: Blockchain Based Customer Loyalty Program in Malaysia Apparel Industry	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Go through FYP 1 program progress and proceed with it

2. WORK TO BE DONE

- Check what function need to be added into the system

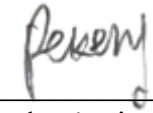
3. PROBLEMS ENCOUNTERED

- No problem

4. SELF EVALUATION OF THE PROGRESS

- Good progress

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 4
Student Name & ID: Chew Pek Eng & 20ACB01940	
Supervisor: Dr. Gan Ming Lee	
Project Title: Blockchain Based Customer Loyalty Program in Malaysia Apparel Industry	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Made a checklist for to-do functions

2. WORK TO BE DONE

- Write the function according to the to-do list

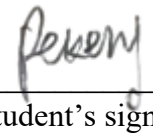
3. PROBLEMS ENCOUNTERED

- No problem

4. SELF EVALUATION OF THE PROGRESS

- Good progress

Supervisor's signature



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 6
Student Name & ID: Chew Pek Eng & 20ACB01940	
Supervisor: Dr. Gan Ming Lee	
Project Title: Blockchain Based Customer Loyalty Program in Malaysia Apparel Industry	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

2. WORK TO BE DONE

- Writing main function
- Write smart contract for Redeeming Loyalty Reward Escrow Service and Claiming Loyalty Point

3. PROBLEMS ENCOUNTERED

- No problem

4. SELF EVALUATION OF THE PROGRESS

- Need to spend more time on writing functions

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 8
Student Name & ID: Chew Pek Eng & 20ACB01940	
Supervisor: Dr. Gan Ming Lee	
Project Title: Blockchain Based Customer Loyalty Program in Malaysia Apparel Industry	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Completed writing smart contract
- Completed all main functions of the system

2. WORK TO BE DONE

- Adjust the layout of the system

3. PROBLEMS ENCOUNTERED

- No problem

4. SELF EVALUATION OF THE PROGRESS

- Need to spend more time on doing the layout

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 10
Student Name & ID: Chew Pek Eng & 20ACB01940	
Supervisor: Dr. Gan Ming Lee	
Project Title: Blockchain Based Customer Loyalty Program in Malaysia Apparel Industry	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Completed the layout of the system

2. WORK TO BE DONE

- Modify some diagrams in Chapter 3 and 4 (System Methodology/Approach and System Design)
- Chapter 5 - System Implementation (Screenshot the system operation)
- Chapter 6 - Testing Setup and Result
- Chapter 7 - Conclusion and Recommendation

3. PROBLEMS ENCOUNTERED

- No problem

4. SELF EVALUATION OF THE PROGRESS

- Good progress

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3, Year 3	**Study week no.:** 12
Student Name & ID: Chew Pek Eng & 20ACB01940	
Supervisor: Dr. Gan Ming Lee	
Project Title: Blockchain Based Customer Loyalty Program in Malaysia Apparel Industry	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Modified some diagrams in Chapter 3 and 4 (System Methodology/Approach and System Design)
- Chapter 5 - System Implementation (Screenshot the system operation)
- Chapter 6 - Testing Setup and Result
- Chapter 7 - Conclusion and Recommendation

2. WORK TO BE DONE

- Finalizing report
- Send report for draft checking and report submission
- Record demo video for the presentation

3. PROBLEMS ENCOUNTERED

- No problem

4. SELF EVALUATION OF THE PROGRESS

- Good progress

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Student's signature

POSTER

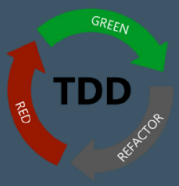
Blockchain-Based Customer Loyalty Program (CLP) in Malaysia Apparel Industry

UTAR
UNIVERSITI TUNKU ABDUL RAHMAN

INTRODUCTION

- To resolve apparel CLP users' data privacy and security issues
- To enhance the payment security measures by Blockchain-based Escrow Agent
- To provide Blockchain-based approach in obtaining and spending loyalty points
- To increase the comprehensive transparency of the apparel product lifecycle

METHODOLOGY



Test-Driven Development (TDD) is a type of agile methodology and coding practice where tests are written before the actual code, ensuring that software is thoroughly tested from the outset. Three phases: Red, Green, Refactor

DISCUSSION

This project introduces an innovative CLP to Malaysia's apparel industry. In 2021, Malaysians have been scammed for RM58 million to online shopping. It addresses the issue of online scams, providing enhanced security through decentralization and an escrow system.

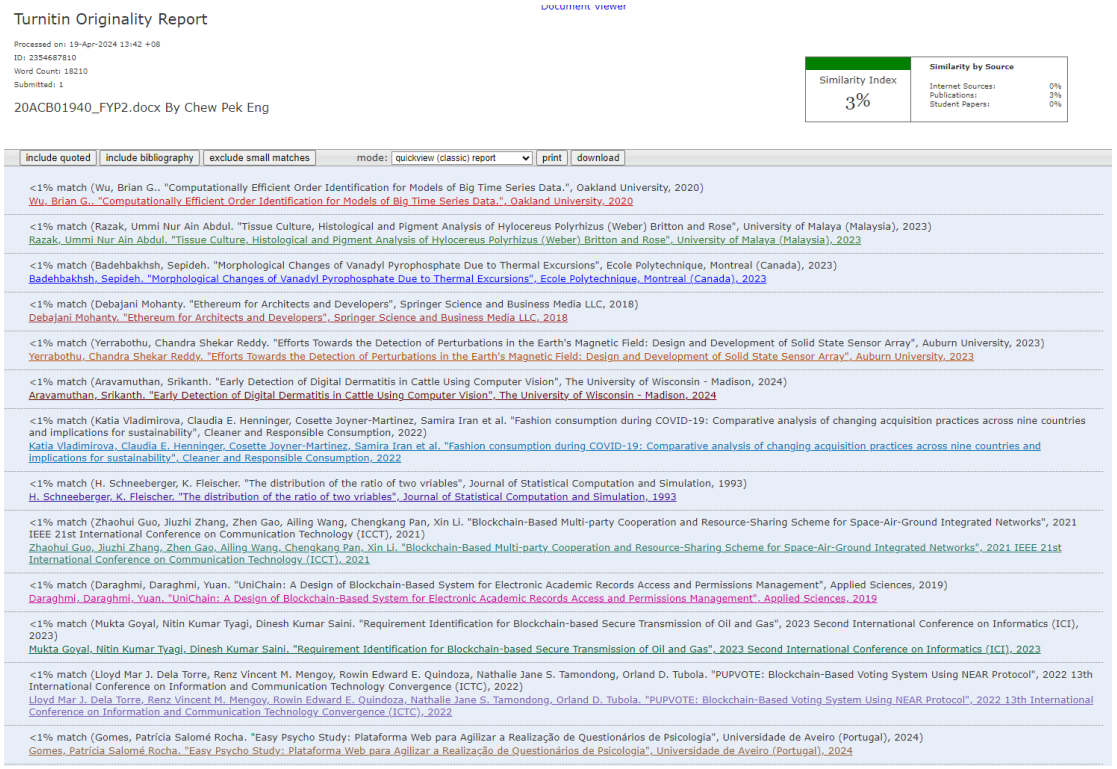
CONCLUSION

This project brings benefits to apparel CLP users and businesses. It enhances data security through decentralization, boosts trust with an escrow system, and allows collaboration with other programs. The NFT collection system adds fun and transparency increases trust for users and businesses.

Project Developer: Chew Pek Eng

Project Supervisor: Gan Ming Lee

PLAGIARISM CHECK RESULT



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Full Name(s) of Candidate(s)	Chew Pek Eng
ID Number(s)	20ACB01940
Programme / Course	Bachelor of Information Systems (Honours) Business Information Systems
Title of Final Year Project	Blockchain Based Customer Loyalty Program in Malaysia Apparel Industry

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Name: Gan Ming Lee

Date: 22/4/2024

Signature of Co-Supervisor

Name: _____

Date: _____

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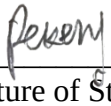

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