MAKER'S INVENTORY SYSTEM: A LOGICAL-BIN STORAGE APPROACH

BY

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A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

In partial fulfillment of the requirements

for the degree of

BACHELOR OF INFORMATION SYSTEMS (HONS) INFORMATION SYSTEMS ENGINEERING

Faculty of Information and Communication Technology

(Kampar Campus)

JUNE 2020

REPORT STATUS DECLARATION FORM

Title: Maker's Inventory System: A Logical-bin Storage Approach

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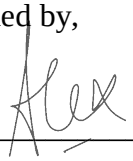

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ACKNOWLEDGEMENTS

I would like to express my sincere thanks and appreciation to my supervisor, Dr. B.Y Ooi who has given me this bright opportunity to engage in this inventory system project.

To a very special person in my life, Jeremy Teh, for his patience, unconditional support and love, and for standing by my side during hard times. Finally, I must say thanks to my parents and my family for their love, support and continuous encouragement throughout the course.

ABSTRACT

This project is an inventory system which is built especially for the makers. Makers often like to develop thing creatively by themselves and have many equipment or tools with them. Therefore, this system has come to help the makers to store their items. Normally, an inventory system used to keep every items accordingly which we called this technique as static slotting. However, the drawback of this method is to require many containers to store the items. Container acts as the storage for the item. Every items are categorized and store in the container according to their types. When a new type of item shows up, the makers have to add a new container to save the item. As a result, the containers will use up the physical spaces in order to place them. For this maker's inventory system, the system will optimize all available spaces and use dynamic slotting method inspired by the Amazon's chaotic storage approach. The makers can place any items in any containers without concerning the types of the items. This can decrease the amount of containers needed and saves spaces. The makers can manage this inventory system by performing Create, Retrieve, Update and Delete (CRUD) operations on each items and containers. The makers can also create and print out new barcode for the items and containers. Once the makers scan the barcode on the item using this system, they are able to locate which container has the respective item that they wanted to access. Similarly, the makers manage to find out all the items in the respective container by scanning the barcode on the container without the need of searching the containers one by one to look for the item. The makers can always check on the status of each items, for an example, the quantity of the items. They can decide when to restock. This inventory system also provides the feature for stock checking for makers.

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LIST OF ABBREVIATIONS

API	Application Programming Interface
CRUD	Create, Retrieve, Update and Delete
CSS	Cascading Style Sheets
DIY	Do-It-Yourself
SKUs	Stock Keeping Units
RDBMS	Relational Database Management System

Chapter 1: Introduction

1.1 Problem Statement

There are there problem statements that can be identified in this project. The first one will be the challenge of target user has too many items to store and does not store the items in correct way. This leads to more storage needed to keep all the items and excessive use of containers that need more room to place the containers which will occupy the physical space.

The next problem statement is user not able to know the real-time information or status of the item stored. The items are stored separately in different boxes. Therefore, the user might need to check each box to look for the respective item. The box contains many items in it, so the user has the higher chance to miss out the item.

As mentioned in the second problem statement, the user needs to search the box one by one to find the item. The speed of finding out and accessing to the item is slow. This causes that the user needs to use up a lot of time when the item is in the last box, which is the worst case for this situation.

1.2 Background and Motivation

Nowadays, people like to create new projects or develop new things by themselves during their spare time. They carry out the Do-It-Yourself (DIY) method to build something which means creating thing without the help of any experts or professionals. They like to make this activity as their hobbies which we called these people as "makers". Normally, a maker will store his components accordingly in his inventory physically. The maker usually needs to access to the components in order to work on his project. The maker will face difficulties if the components needed are no longer contained in the inventory and he unawares about it until he searches for it. Therefore, it is better if there is a system for the maker to keep track the quantity of the components from time to time.

The title of this project is "Maker's Inventory System: A Logical-Bin Storage Approach". This project is about creating and working on an inventory system which is a website application that targets on makers and people who have the problems in storing items. All the items in this inventory system are stored in each single bin logically. Users can store and retrieve their items in and from each bin or container. Different items are stored inside each bin to minimize the quantity of bins. This inventory system is introducing the approach like "chaotic storage" inspired by Amazon.

Figure 1.2.1 Chaotic Storage in Amazon (Random Stow 2018).

The Amazon started their business on website since 1994 and expanded their business all over the world (Amazon Startup Story). Now, Amazon is one of the largest online retailers, functions as cloud computing platform provider and provides other technologies. In the year of 2005, Amazon changed the traditional way to manage their warehouse into chaotic approach (Van den Berg, 2016). This helps to utilize all the spaces in order to store more items and increase the speed of accessing items for their customers. Amazon used this method to optimize every spaces of their warehouse by placing different types of items randomly in any available locations. This method also leads to improving the flexibility of process because this method can avoid from wasting any storage space which immediately filling up the empty spaces once not in use (Robinson, 2017). Every stored item has its own barcode. The barcode is scanned and data is stored in to the system before placing the item in the bin. These barcodes are used to retrieve the information from the computer system. The employee can easily access to the location of the respective item according to the information.

The management system of Amazon keeps on evolving in order to provide better online shopping experiences for their customers, to improve the speed of picking up and packing the orders and speeds up the delivery time. Amazon used automation for their warehouse management in the recent years. They operate their warehouse using Kiva robots by Kiva Systems. The robots can help to pick up and move the items without any assistance and speed up the work (Heater, 2019).

Figure 1.2.2 Amazon's Kiva Robots (Autonomous Robots 2014).

In this project, the inventory system that will be developed is a minimized warehouse system implementing the chaotic storage system. The features that are included in this system are:

1. Allows static and dynamic slotting for the items.
2. Stores barcode's information of containers and items for retrieving process.
3. Stores details of items for users to keep tracking the status anytime.
4. Allows products checking using barcode scanning.

1.3 Objectives

The purpose and aim of this project is to develop a simple inventory system is to solve the storage problem faced by the people, especially the makers. There are three main challenges that faced by the makers. Firstly, the large amount of items they wanted to store. Next, the problem is to keep track of the quantity and status of items in the inventory. Lastly, the makers want to access to their items fast. The main objective of this project is to utilize every available space in the storage in order to optimize the spaces. With the system proposed, users can place their items randomly and freely in any containers. They do not have to waste their time on arranging or categorizing their items accordingly for easy searching and they can have lesser containers to keep the items. They do not have to worry about lacking of containers. They can easily know about the exact location of the item and identify the status of the items by using the web app. This makes the situation becomes more convenient. The main objective can be divided into two sub-objectives.

The first sub-objective is to improve the speed of accessing items and retrieving items information from the inventory system. The speed of processing is important. For an example, there are two situations where one of the users use the traditional way of managing storage while another one use the proposed inventory system but the speed of processing the work is the same. Therefore, it is no point for the users to waste their time and money to have the new proposed system.

The second sub-objective is to increase the amount of quantity items that can store. The users do not need to purchase many containers to keep their items. As mentioned about, they do not have to arrange and categorize the items so they can place their items as many as the container can hold all the items.

1.4 Proposed Approach / Study

The proposed approach which is used to solve all the problem statements that are mentioned earlier is by developing a web application that can utilize the scanning and barcode system. The user does not have to type in or key in many inputs as most of the process is done by selecting options and scanning barcode. Therefore, the user able to store the items as many as the storage can hold without wasting much of time.

For this system, the user does not have to worry about the categorization of items. Different types of items can be placed in the same storage or container. This enable the user to fully utilize the spaces of the storage. The user also can keep track on the status or situation in the storage even though there are various items in it. This is because the storage and the item are having the barcodes that created by users earlier. These barcodes can retrieve the information and display it to the user. This minimize the work for user to search for item one by one from each storage.

The target user which is the maker, will always have different projects and the item in the storage might be missing sometimes. So, there is a product checking feature which allows the user to check the storage in order to find out the lost items and remove it from the system. The process for product checking is start by scanning all the items in the storage that needs to be checked. Then, the system will display the items that are not scanned which means that the items are no longer in the storage. The user can choose to remove it from the storage or just leave it.

Lastly, the user needs to “check-out” the item when he takes out the item from the storage. This can be done by scanning the item’s barcode. When the user wants to place back or place the items in different storage, he will need to scan the item’s barcode again and the storage’s barcode that wish to be placed so that the item can be “checked-in”.

1.5 Highlight of What Have Been Achieved

The first thing that achieved in this project is allowing the target user to make use of all the spaces to store the items. The user does not need to prepare a lot of containers or storages to keep the items. The work for categorizing the items according to the type of item is not needed. The user can store different items in the same container freely without any concern.

Next, this inventory system let the makers to carry out their work more efficient and faster. They can track their components using the system from time to time. They do not have to search every container to find out the needed item. They able to process their work in a shorter time and the speed of accessing items is very fast.

Lastly, the makers are able to complete their work on time without any delay. They also will not face the problem of lacking components or equipment in the halfway of their work. This is because they can perform product checking on the containers whenever they want to in order to make sure the availability of the components. Therefore, they can prepare and plan to restock components that are not enough or purchase the needed equipment before starting their project.

1.6 Background Information

Inventory is the availability of products or complete list of stock left (Kenton, 2019). Inventory management is important for makers as they have to store tools and materials that they wanted to use. It must be difficult for them to continue their work when there are shortage of tools or materials. Therefore, it is better if they can prepare everything before starting to develop their thing. Through this inventory system, they can visualize the status of every items and plan when to stock up their items. Besides, the makers also able to access their item very fast during their work. They do not have to search one by one to find out the item that they wanted to use. This saves up their time to complete their task. The concept of this inventory system is using the dynamic slotting method which allows the makers to store thing randomly. They do not have to concern about the classification of items and the need of adding more and more containers to keep their items.

In the early days, inventory is managed in a traditional way. People have to keep their eye on every item which is sold and how many are left. They have to jot down every records in their book. Most of the time, people may record it wrongly as there are large amount of items to be included and many books are needed to keep all the records. It is hard for them to track back the status of item as they have to find out the location of the record in the books one by one. So, people are unable to predict the future needs for themselves and this will decrease the efficiency of doing work and causing problems.

The traditional way of managing inventory is not effective. Nowadays, barcode is created for people to scan and get the information about the item. The barcode is the identification for the item. People do not have to waste time on retrieving the information of the item. For an example, once the scanner scans the barcode on the item, the name and price of the respective item will be listed out. The user only has to control and manage their items by using the computer and it is more efficient.

There are two ways to store and manage the inventory. The first one is the static slotting. Static slotting is assigning a fixed location for an item. When the item is

removed from the respective location, the same type or the same item is being placed back to the exact same place next time. For dynamic slotting, the item is placed randomly. All the items which are same or different types can be placed in the same location. There is no fixed location to be assigned for the item.

In this inventory system, the barcode can be created and printed out for each items. The makers can add the item and create their desire barcode. After adding the item's barcode, they have to choose the container that they wanted to store the item. They can scan on the container's barcode to view the items inside the container. This saves up their time to search for item. Moreover, they can perform product checking by scanning the item's barcode in the container. If the system receives the barcode information correctly, it will complete the checking process which means the container has all the item and no item is missing.

1.7 Report Organization

In this project, there will be seven chapters which include the introduction, literature review, system design, design specification, system implementation, system testing and conclusion. The introduction part talks about the problems that are identified for this project and the proposed solution to solve the stated problems. Moreover, objectives and background of this inventory system are also discussed in this chapter. This chapter also highlights the things that have been achieved by this project. In Chapter Two, there are a few studies are identified like the definition of different slotting types and their advantages and disadvantages. The similar previous work is also being reviewed and comparisons are made between them with the proposed system. Next, Chapter Three discuss the design of the system which includes the specifications and the flow of the system. Methodology involved, tools used and user requirements are included in Chapter Four. The issues when implementing the system also discussed in Chapter Four. Chapter Five will talk about the system implementation with the user interface provided. Next, system test cases will be defined in Chapter Six and the last chapter will be the conclusion and the future work.

Chapter 2: Literature Review

2.1 Literature Review

Slotting is important for the operation to make the inventory more efficient. Based on the business rules and product characteristics, the item is allocated to the respective location (O'Byrne, 2011). Slotting is the process of choosing a location for your item to be placed. Slotting can be categorized into two groups, static slotting and dynamic slotting. Static slotting is the process of assigning a fixed location for the item to be placed; the location is just reserve for the same item only. The location of item in dynamic slotting can be changed and all items can be placed randomly in any location, this practice is similar to chaotic storage approach (Warehouse Management 2015). To identify the best location to store each warehouse Stock Keeping Units (SKUs) is the main objective of slotting (Kofler, Beham, Wagner & Affenzeller, 2014).

According to Batt and Gallino (2019), the authors studied and stated that chaotic storage is an inventory that not stored in predefined places together with similar products, but is instead divided up and allocated to any accessible space and with various SKUs being stored in the same place or bin together. They also mentioned the main advantage of chaotic storage is the effective use of space, resulting in decreased need for total space. There is a need of maintaining a fixed location for an item in other storage location system. But in chaotic storage, an empty space may be used immediately by another item, and the returned item may go to any available space. This brings greater flexibility and greater use of space. However, the authors also listed out the disadvantages of chaotic storage. Chaotic storage increases the complexity and difficulty to the picking method as it needs the picker to search for the correct product in the bin once it reaches the right location. A new step which is the searching process is added because different items share a same location or bin. More items need to be searched on average before they find the correct item which resulting in longer picking times when the pickers face bin with many items. Besides, the problem of working condition in chaotic system is bad when an item is missing from the bin. The pickers are usually needed to find an item within a period of time. Batt and Gallino (2019)

citing McClelland (2012) notes that the picker has to scan every item in the bin in order to show that the item that not found is truly missing.

When referring to Kofler (2015), the author stated the random or chaotic slotting means random assignment of incoming materials to appropriate storage locations available. In scientific literature, chaotic slotting is often used as a basis for results. The practical execution with barcode scanners is simple and easy, the picker traffic across the warehouse is balanced and the utilization of space is high. Furthermore, when the visually similar products or items are not stored next to each other, there are no mix-ups between them. Therefore, with all of the benefits, large retailers like Amazon adopt chaotic slotting in their fulfilment centers. The author also mentioned about the main drawback of this chaotic slotting. The picker has to waste longer travel times to access to the items.

Bigo, Isin and Ruppert (2019) explained the usage of chaotic storage in Amazon. They stated that Amazon utilizes this so-called "chaotic storage" algorithm that optimizes storage through the mediation of databases and writes on the physicality of warehouse construction, stacks and remaining human labor by prescribing organization, motion, procedures and gestures. The authors also listed an example for this algorithm. For an example, storing the 500 copies of book in one location together is not a must when Amazon receives a 500-copy shipment of a specific book. Instead of storing all books in same location, they can distribute the books to various areas of vacant shelf space and their location is registered in the database because the chaotic storage algorithms represent the ability to think about the organization and storage. A human picker who has been working for a week in the warehouse can be more productive than the one who has been working for years. This is because his familiarity of the warehouse with the warehouse layout is not related. The only thing that he has to focus is the speed of accessing and retrieving the item physically by referring to the algorithm using the data stored when the products get into the warehouse. Therefore, when using chaotic storage algorithms, the quantity of training needed by fresh staff is significantly lower. The employees do not need to memorize the entire design or single storage locations of the warehouse. With this benefit, Amazon can potentially more easily replace employee

or hire part-time employee. During the peak times, Amazon also can hire seasonal employee to carry out the work.

According to Kofler, Beham, Wagner and Affenzeller (2014), the authors explained random or chaotic slotting by mentioning that incoming SKUs are allocated randomly to appropriate, accessible storage locations in the random storage model. Random slotting makes the implementation easier and stables the picker traffic in the warehouse. However, this can lead to longer travel times on the downside. In practice and as a performance baseline in the scientific literature, random storage is commonly used.

Tsige (2013) also conducted an experiment and study about storage assignment strategies. The author defines that a storage assignment method (slotting strategy) is a set of guidelines that can be used to assign storage locations to SKUs. The commonly used approaches are either the random or dedicated one. In the author's thesis, the author also explained that random storage practice is each SKU is randomly allocated to an empty warehouse location where each empty location is likely to be chosen for storage. Each incoming pallet is allocated randomly to a location in the warehouse which is chosen with arbitrary way from all eligible vacant locations with equal probability (Petersen, 1997 cited in Tsige, 2013). If the pickers of the order can choose their own storage area, they are likely to choose a location near to the input or output point. As a result, those far from the input or output point can have more empty room on aisles. They called this system as closest open location storage (De Koster et al., 2007 cited in Tsige, 2013). So, it clearly shows that the random storage practice will operate only with a computer system. Tsige also provides some recommendations for a particular warehouse management team when come to implementing storage assignment strategies on different situations. One of the suggestions is the author recommends a warehouse manager to introduce a random warehouse assignment approach when the SKUs are loosely linked in a particular order set.

Ong and Joseph (2014) referred to Rouwenhorst et al. (2000) stating that there are four types of storage assignment practice. One of the practices is random storage. The author mentioned that random storage is an assignment practice where items entering a warehouse are arbitrarily situated in any of the vacant locations available without any consideration. Warehouse using this strategy usually has a decent use of room. However, random assignment makes identification of the item more complicated and time consuming when travel. The closest open location storage is more likely function as the random storage. The difference is closest open location utilizes the nearest storage available location. The incoming items will be allocated to the nearest location from receiving region. This implies that there will be higher utilization of storage locations close the receiving region relative to other locations.

According to Graves et al. (1977), cited in Roodbergen and Vis (2009) stated that there are some methods for assigning items to storage locations in the rack. One of the methods that are commonly used in storage assignment practice for Automated Storage or Retrieval Systems is random storage assignment. All vacant locations are equally likely to have an incoming load allocated to them in random storage. The product will be stored using the first empty location that is found if the closest open location storage is implemented. Closest open location storage will result in an Automated Storage or Retrieval Systems where the bins are full with items at or around the input or output points and increasingly more empty towards the back.

Based on Ramtin and Pazour (2014), there are usually three storage practices for distribution centres and warehouses, which included randomized storage, dedicated storage and class-based storage. SKUs are allocated randomly to the storage locations in the randomized storage. For an example, SKUs are collected at the moment of storage request depending on the availability of storage location. By using randomized storage assignment to allocate SKUs to the storage locations, any point inside or within the rack will be probably to be chosen as a storage location. Storage location decisions are made independently of pick positions for a randomized storage practice. The pick position in the middle of the rack therefore has the shortest anticipated travel time for

retrievals to be carried out. The authors also stated the benefit of a randomized storage practice is an effective utilization of the space.

2.2 Review and Comparison of Previous Work

Currently, there are some applications or software provided the service of helping to manage inventory for people. These are some of the examples of inventory system which having the high users' reviews and Table 2.3.1 shows the comparisons between them with proposed system.

The first one is the Zoho Inventory. Zoho Inventory allows businesses to automate their order and inventory management and maintain track of shipment to create smart business choices. This system is appropriate for all scales and branches of e-Commerce businesses and it integrated with various cloud distributors and most common shipping systems. The pricing system is flexible and plans are intended to satisfy the requirements of start-ups and on-budget firms at an affordable price. The inventory system follows from the time the item was ordered to the final shipping time. This system also offers mobile tracking for both Android and iOS devices. The system also let users to regulate inventory sell, handle HR and client interactions from a single platform by using only one single account (Zoho Inventory Reviews).

Figure 2.2.1 Zoho Inventory Management Software Pricing Features Review (Techloyce, 2017).

Next, is the Brightpearl. Brightpearl allows retailers to use one-place management of their orders, inventory, real-time billing and reporting and client information. This system provides real-time client purchasing behavior, SKUs and channel profitability, cash flow, inventory and more (Brightpearl Reviews). The

location management of Brightpearl can be separated into three levels which are no location management, standard locations and multiple concurrent locations. The multiple concurrent locations can allocate the items delivered to a different location and in the end getting the same item spread across the various locations simultaneously (Brightpearl Warehouse locations).

Figure 2.2.2 Brightpearl Inventory Management (Algopix, 2019).

The third inventory system is the Syspro. Syspro is designed for the manufacturing sector to allow businesses in this industry to synchronize, integrate and regulate their production process. Users can install on-premises or deployed in the cloud. Syspro can let users to achieve warehouse automation's high demand by effectively managing distribution. This system also provides inventory optimization capabilities. Syspro let users to find out potential problems (SYSPRO Review).

Figure 2.2.3 Syspro – Review 2018 (Needleman, 2018).

The last inventory system is the Oracle NetSuite OneWorld. This inventory system provides worldwide business platform for multi-subsidiary and multi-national enterprises. It automates all financial aspects of selling. Businesses are allowed to consolidate various account charts effectively, providing real-time visibility and assisting user to view the information at the end of a period using this system. Besides, this system also provides a single, clean client record across subsidiaries to worldwide businesses by getting rid of repeated client records, decreasing information entry mistakes and handling clients effectively (NetSuite OneWorld ERP Review). Locations with bins are provided in order to give a finer tracking rate. Any item can be kept in any locations after the locations and bins are defined (NetSuite, Inventory Management).

Figure 2.2.4 NetSuite OneWorld - Review 2018 (Needleman, 2018).

2.3 Highlight and Compare Proposed Study with Previous Work

Table 2.3.1 Comparisons Between Different Inventory Systems with Maker's Inventory System.

Name of the inventory systems	Zoho Inventory	Brightpearl	Syspro	Oracle NetSuite OneWorld	Maker's Inventory System (Proposed Approach)
Ease of Use	High	Low	High	High	High
Mobile Apps	Yes	Yes	Yes	Yes	No
Bin ID	No	Yes	Yes	Yes	Yes
Scan Barcode / QR code from smart phone or table	Yes	Yes	Yes	Yes	Yes
Barcode / QR code	Yes	Yes	Yes	Yes	Yes
Low inventory warning (Stock)	Yes	Yes	Yes	Yes	Yes
Static or Random slotting	Static	Both	Both	Both	Both
Community	No	No	No	No	Yes
Interact with client	Yes	Yes	No	Yes	No

Chapter 3: System Design

3.1 System Specification

Register and Login

The login part is the entry point of this system. The user will be prompt with a login form which consists of username and password. When the user logins, he will need to provide the credentials to submit to the system so that the system can verifies and authenticate him. After the user being authenticated, he will be direct to the home page of the web application. The system will deny the user to access to the web application if the credentials are provided incorrectly. For the registration part, every user will need to sign up with unique username and email address.

Storage and Item

After the user can access to the web application, he can start to create storage in system. The quantity of storage created is according to the current physical container or storage that the user is having now. For each created storage, the user can add item into it. This means that he will need put all the added items in the respective storage in reality. The system will auto-generate the barcodes for all the created storages and items. Then the user can print out the barcodes and put on or stick on the storage and item.

The usage of the barcodes is effective when the user wants to know the information of the storage and items that he is having now. The system has a page for the user to scan the storage's barcode in order to identify the items in the storage. Besides, the barcode also saves up a lot of time for user. The user only needs to scan the storage's barcode when he wants to switch the item to the scanned storage. Also, the he will only need to scan the barcodes of the items and the storage when putting back or taking out the items. There is no extra typing or input needed.

Product Checking

Product checking can be done when the user choose the storage need to be checked and scan all the items from the selected storage. When user has scanned all the items in the storage, he can perform to end product checking to identify is there any items lost. The system will display the items that are missing from the storage (which means not scanned before ending product checking) and allows user to choose to remove the items from the system.

3.2 System Design

Overall System

Figure 3.2.1 Use-Case Diagram for Overall System of Maker's Inventory System.

Figure 3.2.1 shows the use-case diagram for the overall system. First of all, the user can choose to login to the system. If the user does not have any account yet, he can register through the system. After login to the system, the user has a two choices. The

first option is creating a new storage for the system and the second one will be choosing the existing storage from the system. The storages must be available in the system first so that the second option can be done. Also, the user can delete and edit the existing storage when the system has the dedicated storages. Next, when the user wants to take out the item in the storage, he will need to perform "check-out" item from the system of the item and perform "check-in" item when storing back the item into the storage. The product checking is provided when the user will to have a complete checking on each storage to find out the missing items and remove it if not found.

User Register

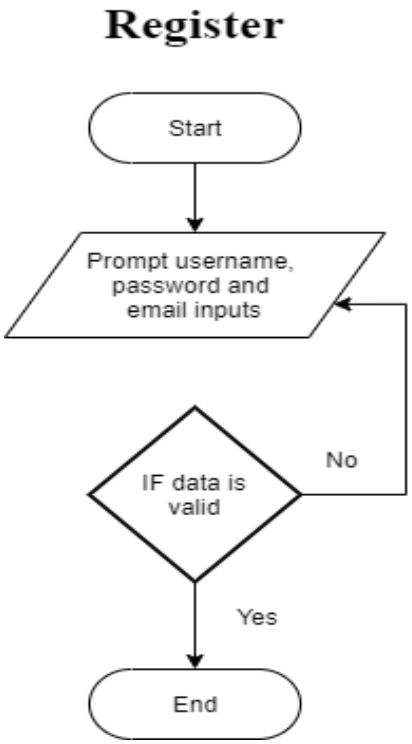

Figure 3.2.2 Flowchart for User Registration.

Before log in to the system, the user must own an account. The user is able to register successfully when he fills out all the valid information and submit to the system.

User Login

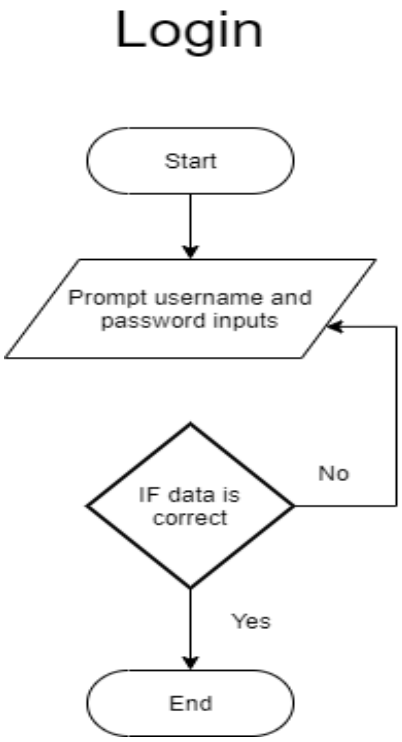

Figure 3.2.3 Flowchart for User Login.

The process for login is similar to the registration. The difference is that user does not have to input email again in login part.

Creating New Storage

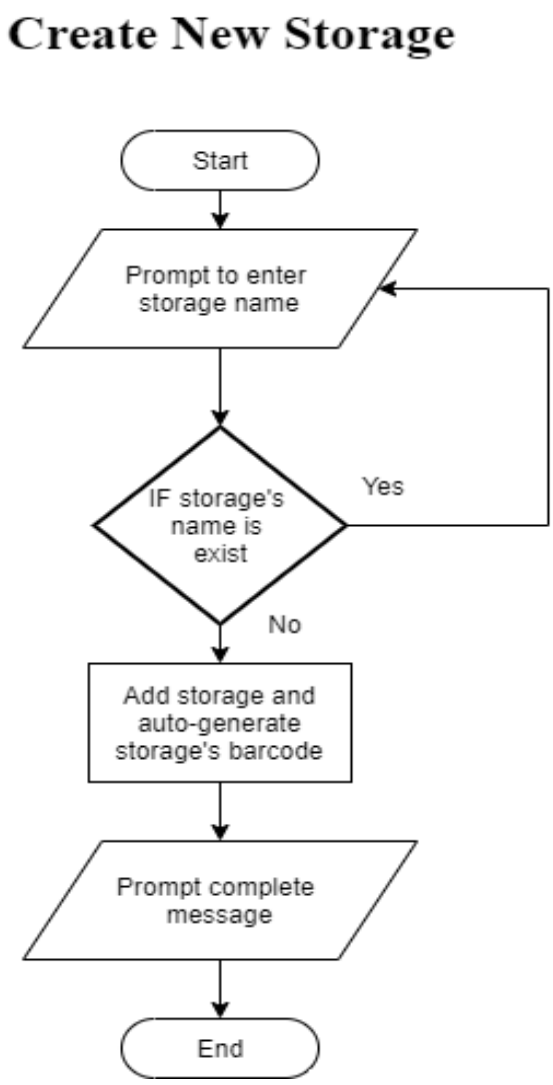

Figure 3.2.4 Flowchart for Creating a New Storage.

Figure 3.2.4 shows the process when user creates a new storage. The storage name must not be repeated in each user's account. After naming the storage successfully, the user can choose to view the created storage. The user must create a storage first in order to proceed to create new items.

Edit Existing Storage

(i) Add Item into The Storage

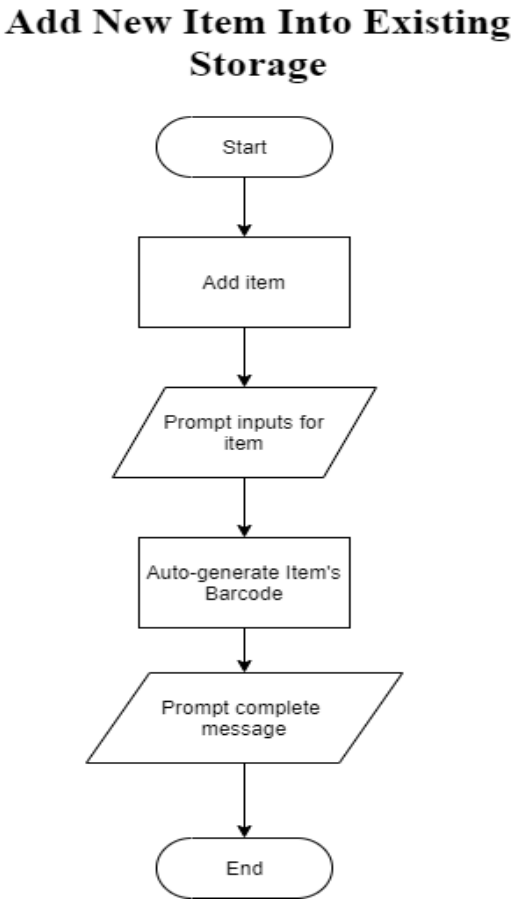

Figure 3.2.5 Flowchart for Adding New Item into the Existing Storage.

When the user wants to add more items into the storage, he will need to provides the name for the item and submit it the system. The system will auto-generate the barcode for the submitted item and store it into the database.

(ii) Update Item

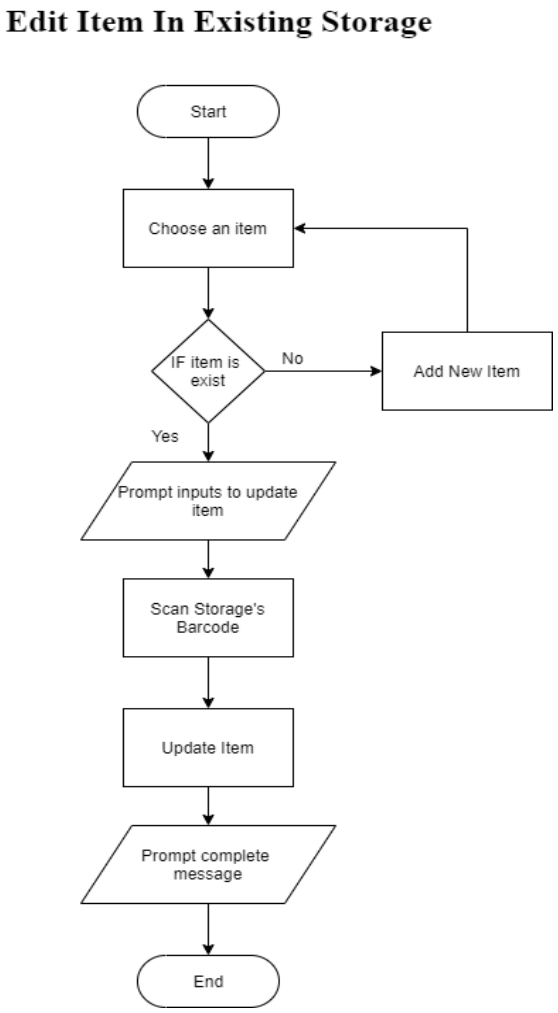

Figure 3.2.6 Flowchart for Editing Item in an Existing Storage.

The user can choose to change the name for the item and change the location for the item placed. For an example, the user wants to change the Item A from Storage A to Storage B, then the user will need to edit the Item A in Storage A and scan the barcode of Storage B. Then, the system will update based on the scanned barcode.

Delete A Storage

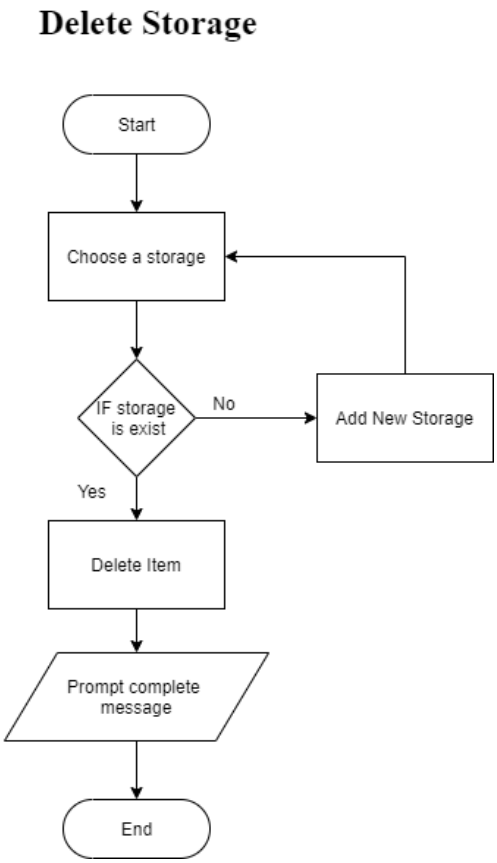

Figure 3.2.7 Flowchart for Deleting Item from an Existing Storage.

The user also can delete any storage that they do not want to use anymore. By doing so, the items that stored inside will also be removed.

Product Checking

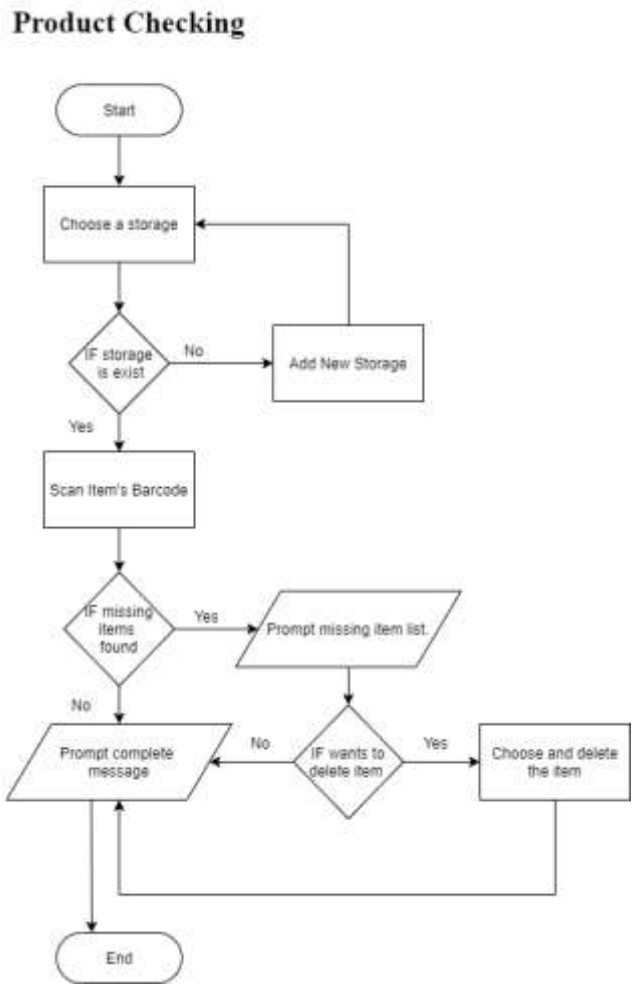

Figure 3.2.8 Flowchart for Product Checking.

Figure 3.2.8 shows the flow when the user wants to perform product checking on the selected storage. When the checking is started, the user needs to scan every items in the chosen storage. After finish checking, the user is able to know items that are missing or the storage is complete.

Chapter 4: Design Specification

4.1 Methodology Involved

Agile Methodology

Figure 4.1.1 Agile Development Life Cycle (Windsor, 2020).

Agile methodology will be the methodology to be use in this system. The system can be modified based on the user requirements in different stages. It provides more flexibility and the test plan will be done after each phases.

First Phase: Project Initiation

This is the starting point and the first phase of the life cycle. In this phase, the value of the system from the user perspective in order to know the benefits in future. The objectives of the project will be identified. The time and cost to develop the whole

system are also estimated. Besides, any internal and external resources need to be counted in during this phase.

Second Phase: Project Planning

In this phase, the user requirements need to be collected from the target users by different ways like interviewing, online survey and others. Besides, the story can be defined in order to identify and estimate how the end user response to the systems or describes the system. The development diagram like the use-case diagram can be drawn to identify the actors in the system and relationship in between.

Third Phase: Project Development

The user requirements should be clearly defined in this phase and the actual work can begin. The project is developed incrementally with high qualities but with less functionality. There will be a few versions produced in this phase and these versions are undergoing different revisions before the final product. At the same time, every versions of the project are being tested once it is completed. This is to find out any error or improvements that can be made into the new version.

Forth Phase: Project Production

This is the phase where the system is officially delivered to the end-user. Testing will carry on in order to fix any bugs or errors that might occur.

Final Phase: Project Retirement

This is the final stage of the agile life cycle. The system is defined as “end of life” when coming to this phase. Some of the reasons for the system to come to the end might be the newer version of the system is produced, no support for the older release and many more. The customers or users will be informed and might request or suggest them to change to a newer release.

4.2 Tools

Language Used

(i) JavaScript

JavaScript is a programming language that is widely used nowadays. It is commonly used in building website and web application which is suitable for this inventory system. It also supports all Cascading Style Sheets (CSS) formats which can allow users to design the web app more interactive and attractive. Besides for developing web application, JavaScript also used in creating a web server by using Node JS which is also used the back end in this system.

Software Used

(i) Visual Studio Code

Visual Studio Code is a source code editor that is commonly used by many users.It provides good support for JavaScript and also the React.Js IntelliSense. Installing various types of extensions in the software may have additional features. It offers a debug, syntax highlighting, smart code completion, snippets and code refactoring platform for users.

(ii) MySql Workbench 8.0 CE

MySQL Workbench is a graphical platform for working with MySQL Servers and databases. It can configure the database like the tables, stored procedures and others. During the development of the project, it is used to check whether the data is correctly modified by visualizing the tables.

Library Used

(i) Front-End: React JS

The first technology involved is the creation of front end by using React JS. React JS is a JavaScript library which used to design simple user interface. It can be

used with many packages that can be downloaded through Node Package Manager (NPM). In order to use the downloaded packages, import it into the JavaScript file (.js or .jsx) and declare it as variable. The front end will take the all the data that input by the users and pass to the database through the back end. It requests data by Rest API using the Axios library.

(ii) Back-End: Node JS

The back end is set up by using Node JS. It will pass the result back to the front end after getting the request. It creates the endpoints to be mapped by the request. The data that is passed in between is set up in JSON format. The back end includes Express JS which provides a simple Application Programming Interface (API) for the server.

Database Used

(i) Database: MySQL

The database system that used in this inventory system is the MySQL which having the relational database management system (RDBMS). It includes the three tables which are user table to store registered user details, storage table to store items for each storage and item table which shows the item list. The queries for each table are created as stored procedure and some queries are also written in the back end (Node JS).

4.3 User Requirements

(i) The user wants to store item with less physical storage and able to know the location of the item.

This inventory system encourages user to store item using dynamic slotting because this can utilize all the available spaces in the storage. Therefore, user does not have to prepare many storages which occupy the physical spaces. It provides barcode for every created storage and item. The user does not have to worry about that all the items are placed in the same storage and will lead to messy situation in which cannot find out the stored item. The barcode provides the item list of the storage and user able to track from it. In the system, it can be done by the search feature. The user only needs to scan the storage's barcode and the system will direct him to the storage with correct item list. Besides, the user can apply filter on the item to search the respective item.

(ii) The user needs to store a lot of item with simple process.

The makers usually have a lot of different items and components because they have many projects to handle. Therefore, this system reduces the process for entering data or information needed. For an example, when the user creates a new item, he only needs to key in the item's name and the barcode is auto-generated by the system. Besides, all the process is in simple way like scanning the barcode and choosing the decisions.

(iii) The user wants to identify items that are missing.

Most of the makers will carry their components and items to anywhere, so they might accidentally forget to keep back their items back to the storage. The system provides a solution to this problem by allowing the user to perform product checking for the selected storage. This solution is also very simple and easy because the user only needs to scan everything in the storage. Then, the system will compare the scanned items with the items recorded in the system. If the item is missing from the storage, the system will display a list of missing items to the user and the user can choose the remove it from the system.

4.4 Implementation Issues and Challenges

During the implementation of maker's inventory system, some issues and challenges have been faced. The first one will be the set up in database table. The creation of table must be correct in order and decide the linking of tables. For an example, the user's id acts as the foreign key for storage's table. When user create a new storage, the user's id must be retrieved and store together as a row. When displaying the list of storage list, the user's id is used to identify the storage that the user owns. Another example is the barcode for each item cannot be repeated. This is because the barcode is used in the scanning process in order to find out the location of the item. If the items have duplicate barcode, the retrieving process will be done wrongly. Therefore, the planning for the table must be done properly.

Another challenge will be the connection between Node JS and MySQL is not stable. When creating a new stored procedure which some validations, the system connected to MySQL but unable to execute the written query. It is not updated and have to restart the system a few times. After restarting the system, the query can be executed. This shows that MySQL is not a very good choice of database to be used in this system or to be used with Node JS. When running the system, sometime the database connection also will have lost when user was going to another page or refreshing the page. This cause that user unable to view the data and have to reconnect the back end or restart the system.

Lastly, the problem that occurred will be the dependencies used by React JS. The dependencies that get from NPM will sometimes include vulnerabilities (low, medium, high and critical stages). It can be fixed through npm audit fix but sometimes the it only provides recommendations about fixing the issues. This is time consuming as the user has to find out the dependency that cause vulnerabilities one by one.

Chapter 5: System Implementation

5.1 System Implementation

Landing Page

Figure 5.1.1 shows the landing interface when the user browses the web application for the first time. The web page will display a form for user to sign in.

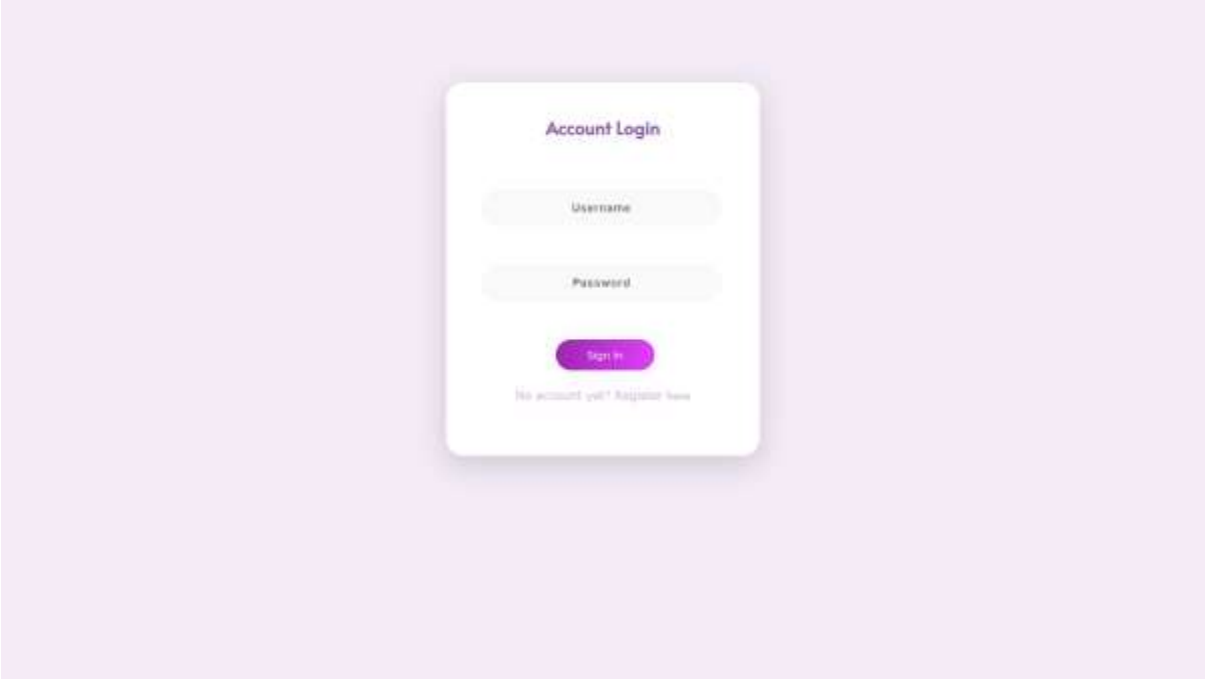

Figure 5.1.1 Landing Page of the Inventory System.

User Login

Validation will be done if the user tries to enter the wrong credentials and user is not able to access the web application if the credentials are invalid.

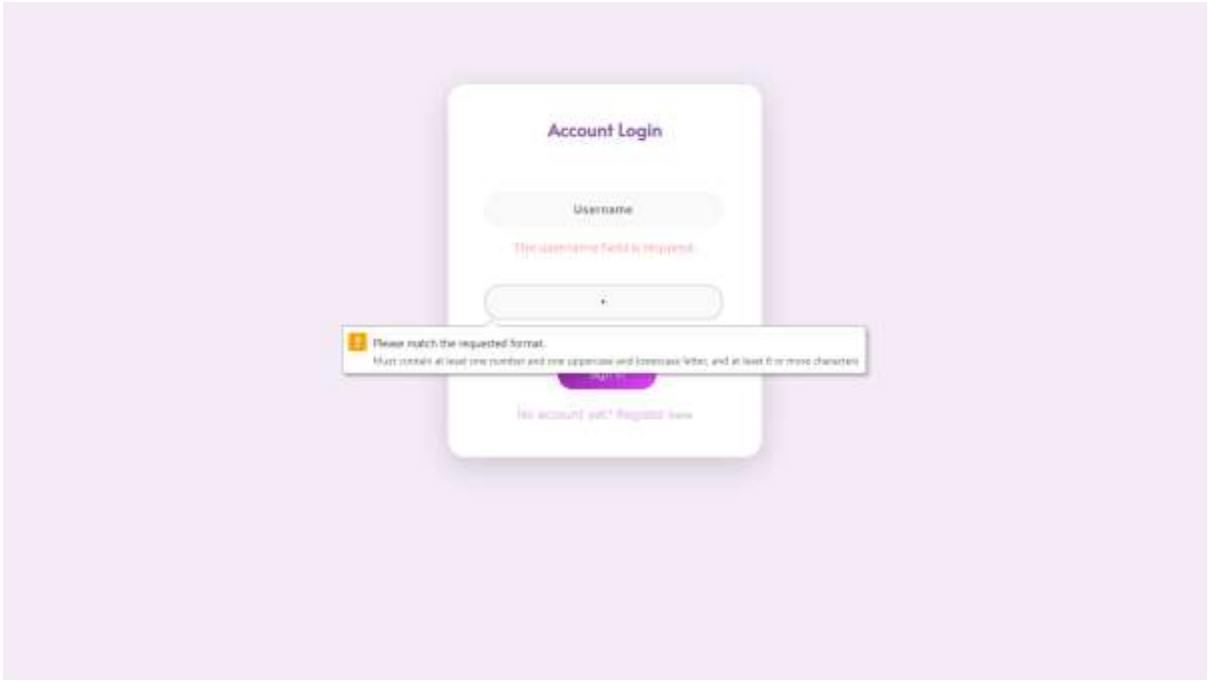

Figure 5.1.2 Incorrect Credentials Entered to Login.

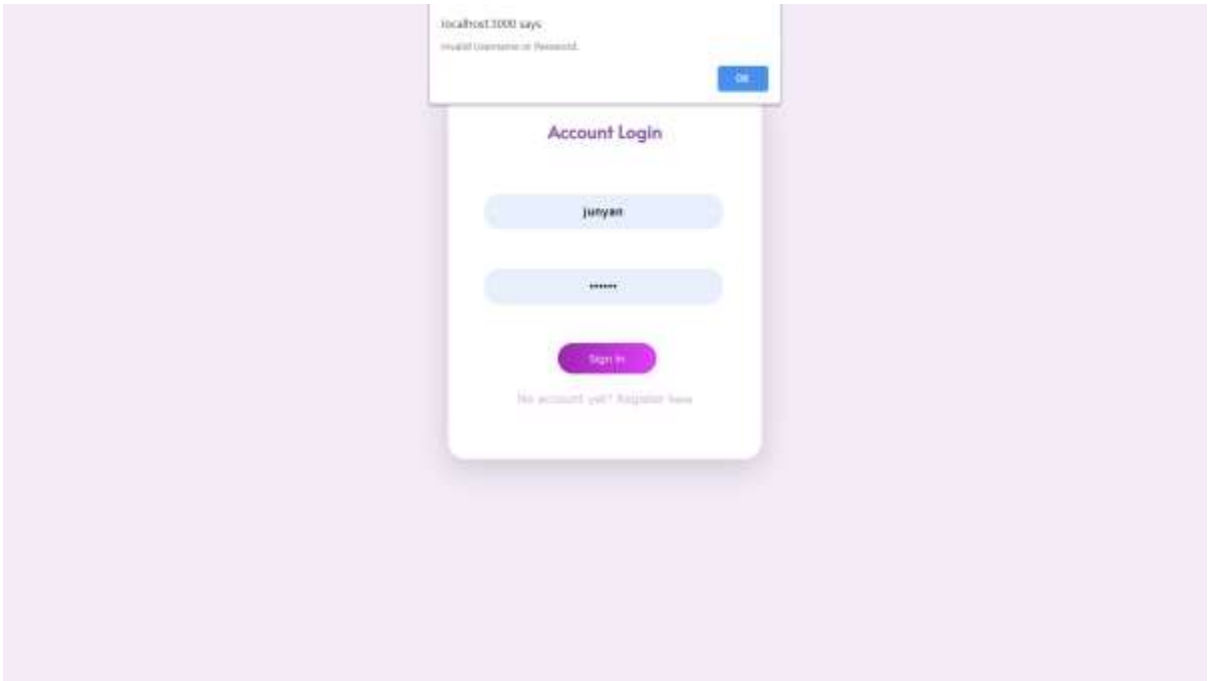

Figure 5.1.3 Invalid User Login.

User Register

User registration form is similar with the login form. The user will need to input the username, password and email for signing up. The username and email is unique throughout the system.

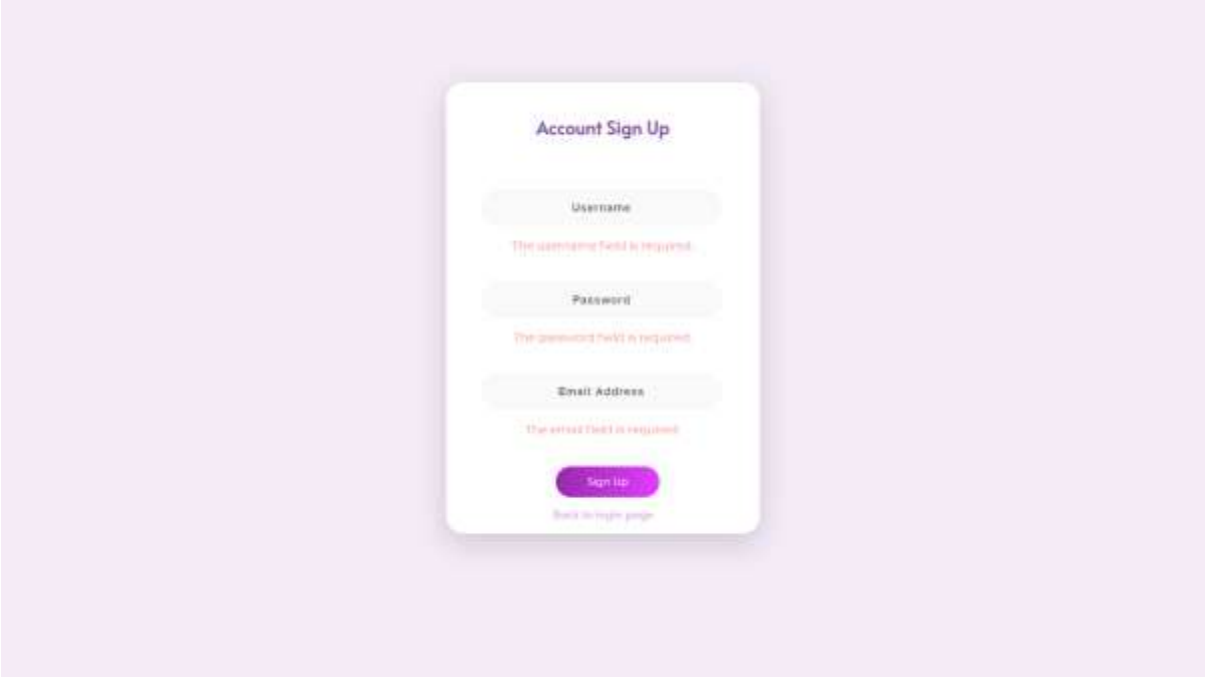

Figure 5.1.4 Incorrect Credentials Entered to Sign Up.

Home Page

User will be direct to the home page of the web application once he has logged in successfully. He has three main options to choose from which are the create new storage, choose existing storage and scan item.

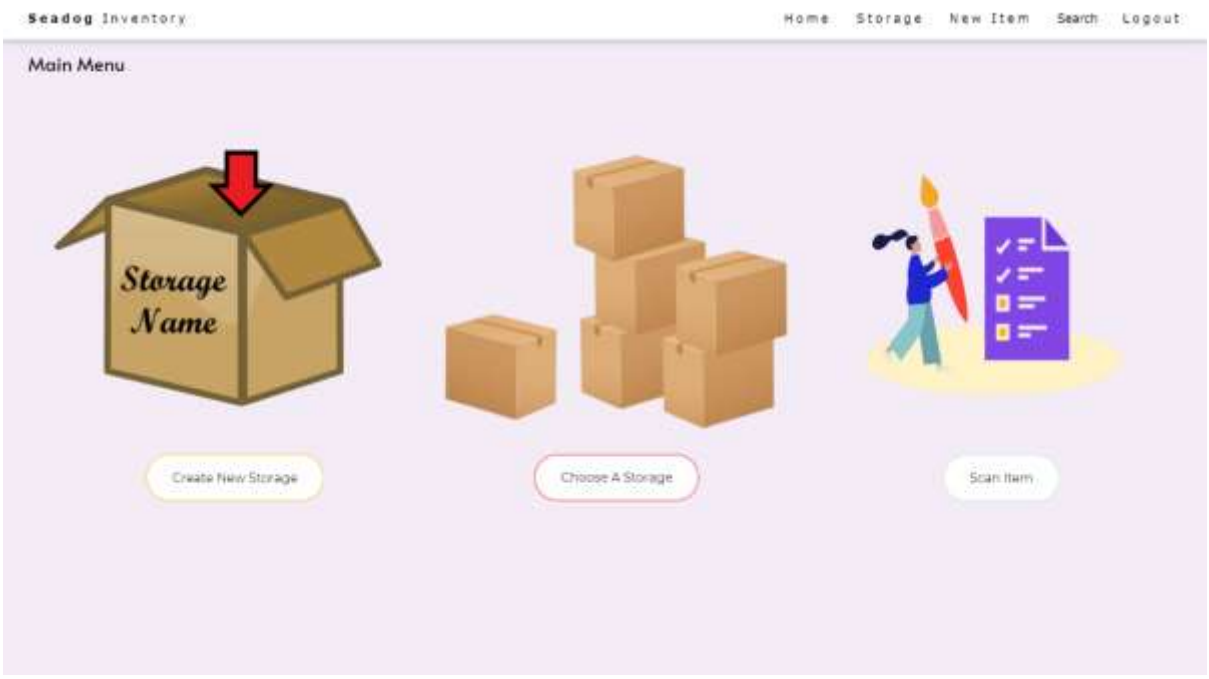

Figure 5.1.5 Logged in User will be Directed to Home Page.

Create New Storage

When the user log in for the first time, the user does not have any created storage in the system. Therefore, he must create a new storage before proceeding to another two options.

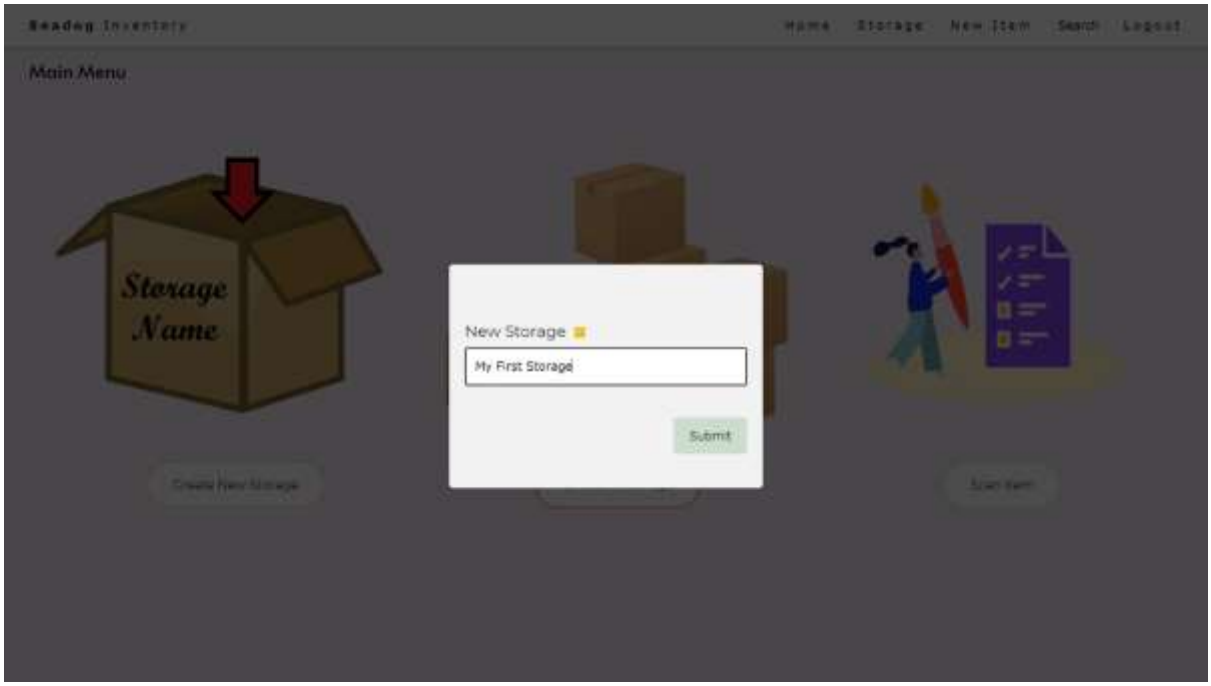

Figure 5.1.6 Create A New Storage.

Choose Existing Storage

After creating a new storage, the user can view the list of storage by accessing the button from the home page (Choose A Storage) or from the navigation bar (Storage). Figure 5.1.7 shows that the storage is created and the barcode generated and is assigned.

Figure 5.1.7 Storage List.

The barcode of the storage can be printed out by click the printer's icon. Then, the user can put on or stick the barcode on the physical storage. When the storage is no longer used or unwanted, the user can remove it but user must take note that removing the storage also remove the items inside the storage.

Figure 5.1.8 Printing Storage's Barcode.

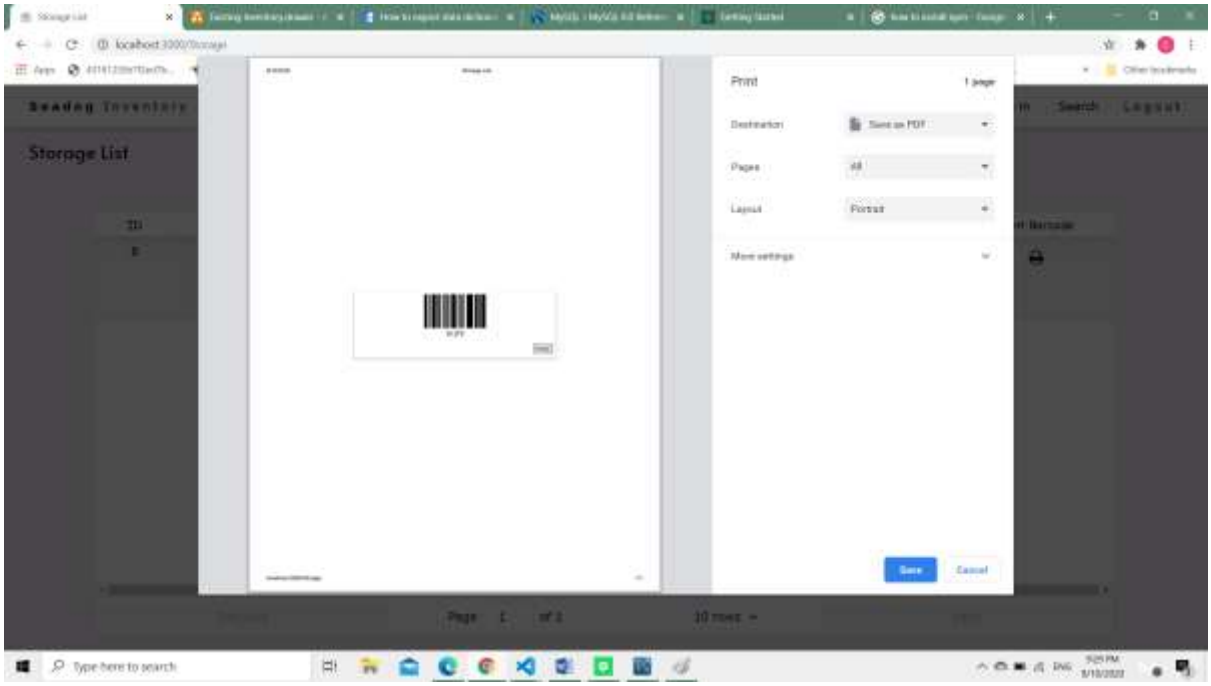

Figure 5.1.9 Printing Storage's Barcode.

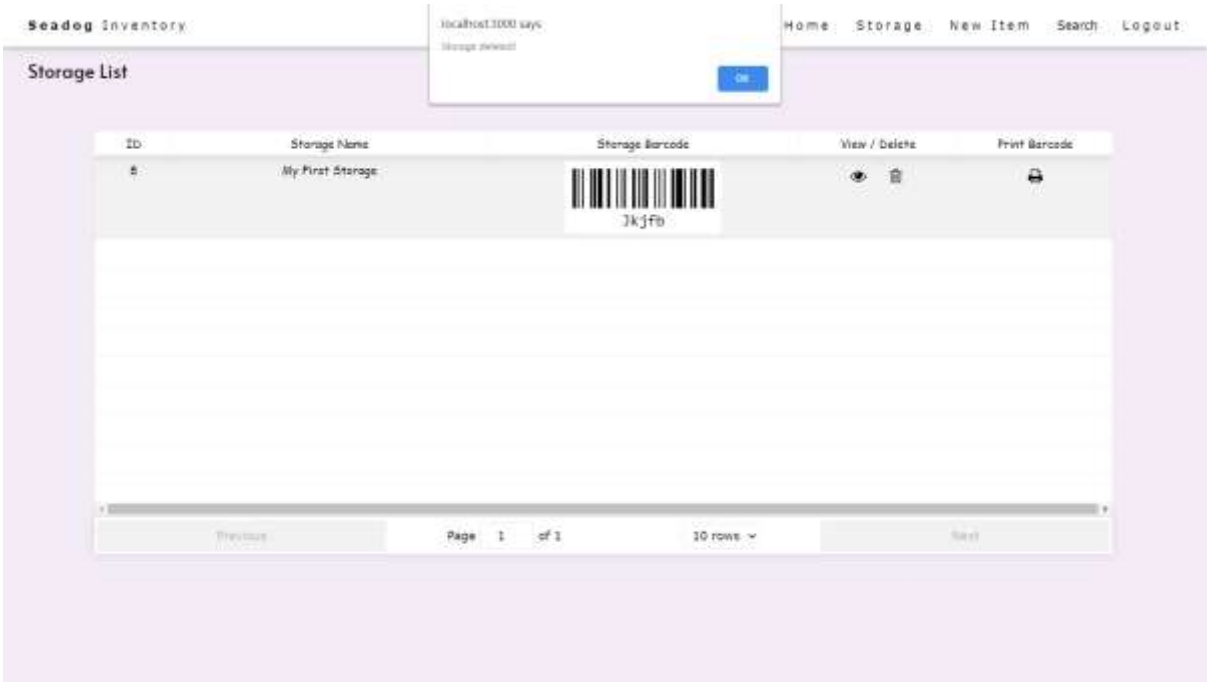

Figure 5.1.10 Deleting A Storage.

The user can view the items in the storage by click the eye's icon. For the first time using the inventory system, there is no item inside it yet. So the user will be prompt with Figure 5.1.11.

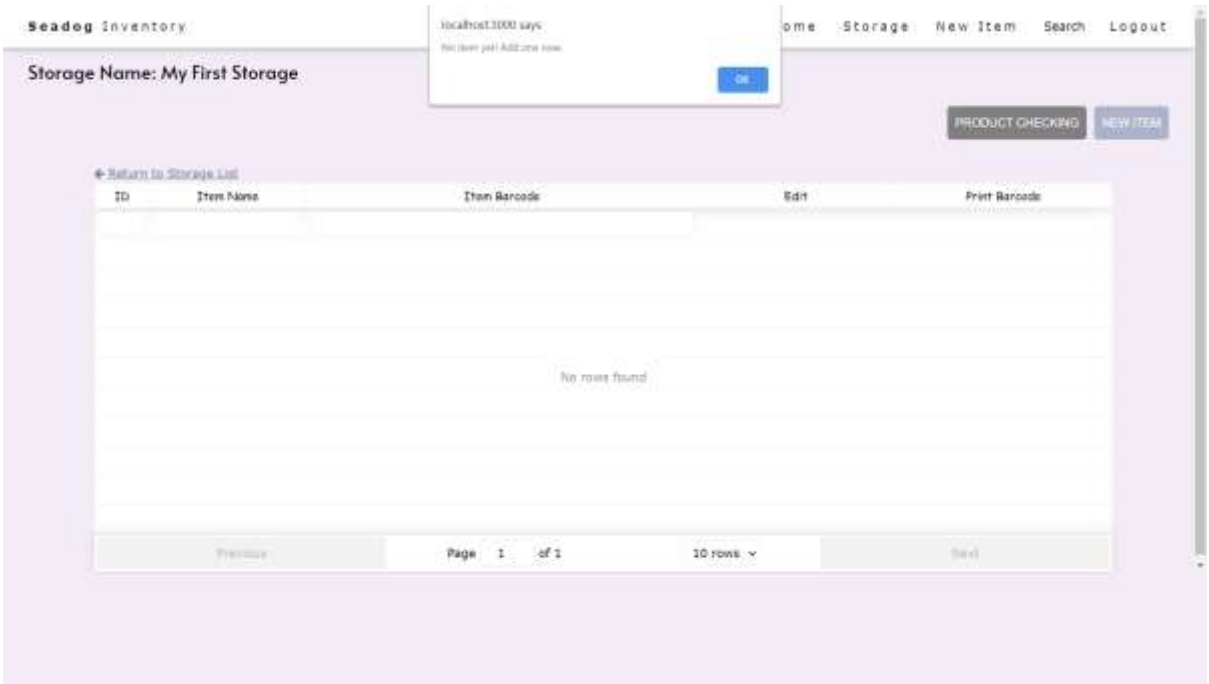

Figure 5.1.11 Empty Storage.

The user can add a new item by click the button (“New Item”) on the top right hand side of the item list. After that, the user will be prompting a form to fill up the new item’s name and a successful message will be shown when the item is added successfully. The added item is shown in the item list in Figure 5.1.13. The item’s barcode also can be printed just like the storage’s barcode.

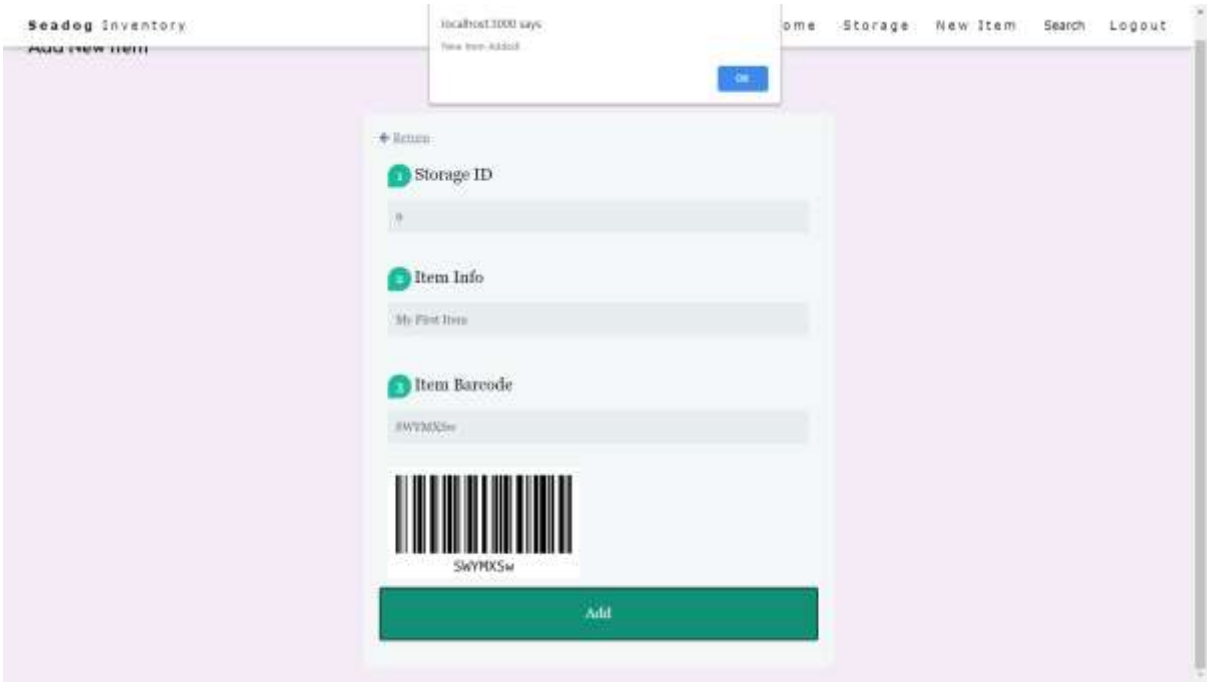

Figure 5.1.12 Add New Item.

Figure 5.1.13 Item list after adding a new item.

The user can change the location for the selected item by clicking the edit button of the item. Once again, the user will be shown with a form and update the needed input. The user needs to scan the storage which user wish to switch the selected item to.

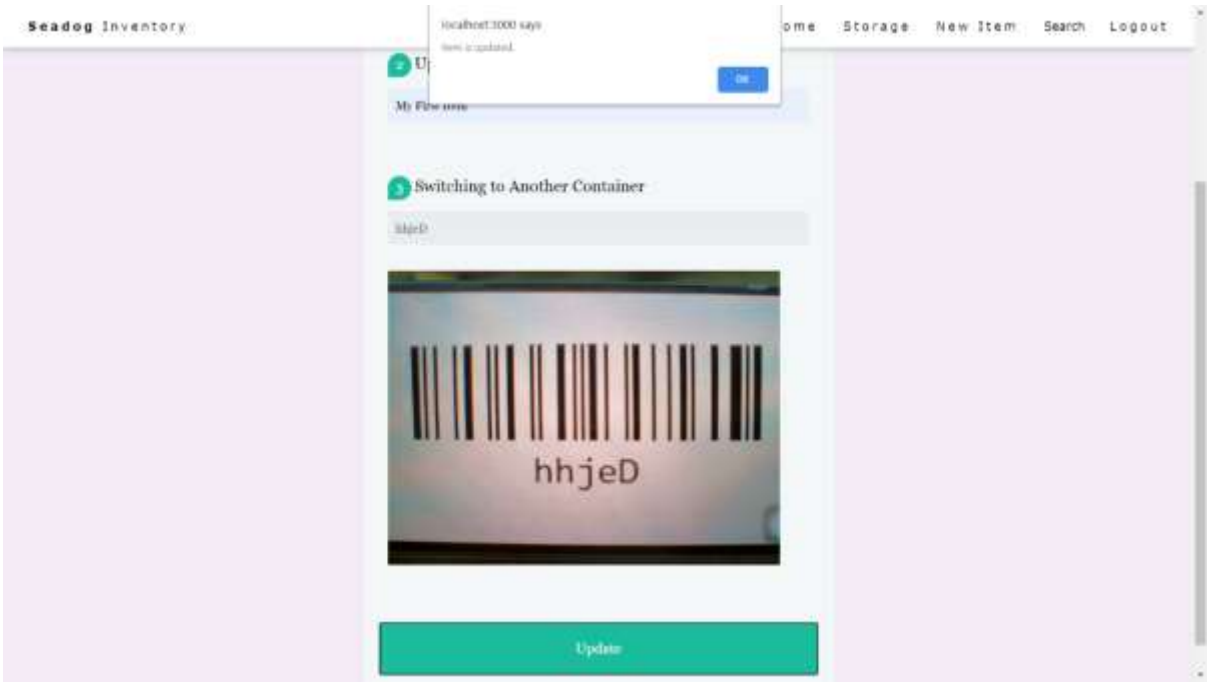

Figure 5.1.14 Item is updated successfully.

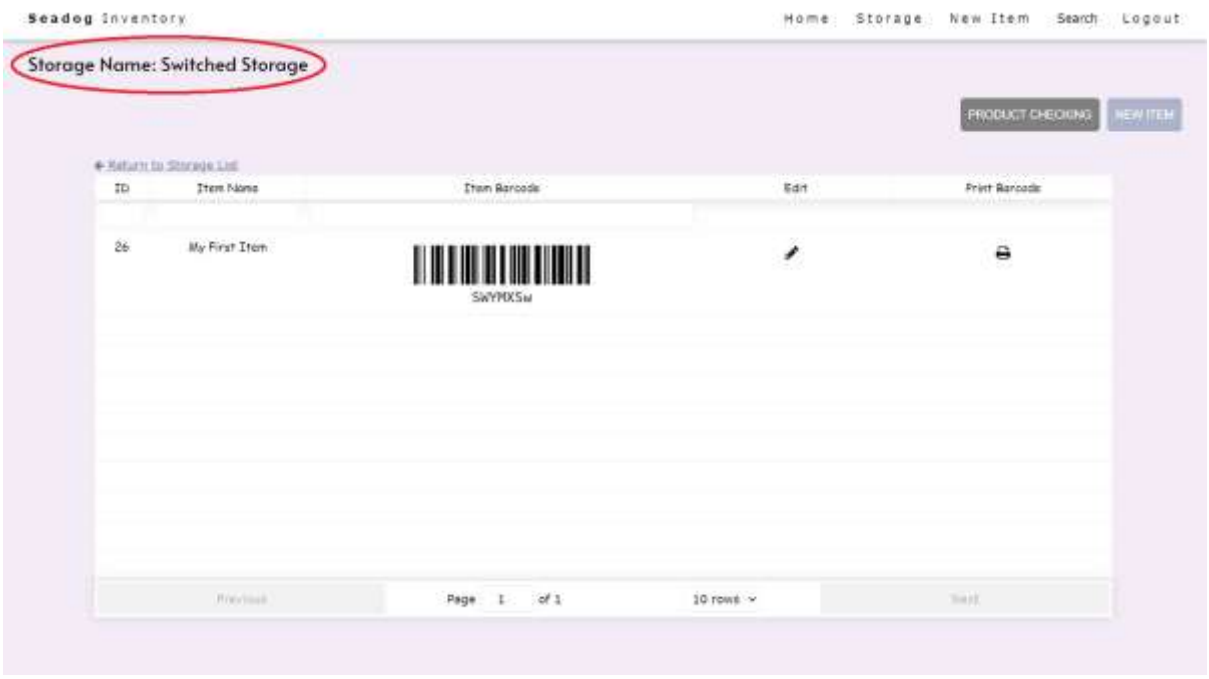

Figure 5.1.15 The updated item is changed from "My First Storage" to "Switched Storage".

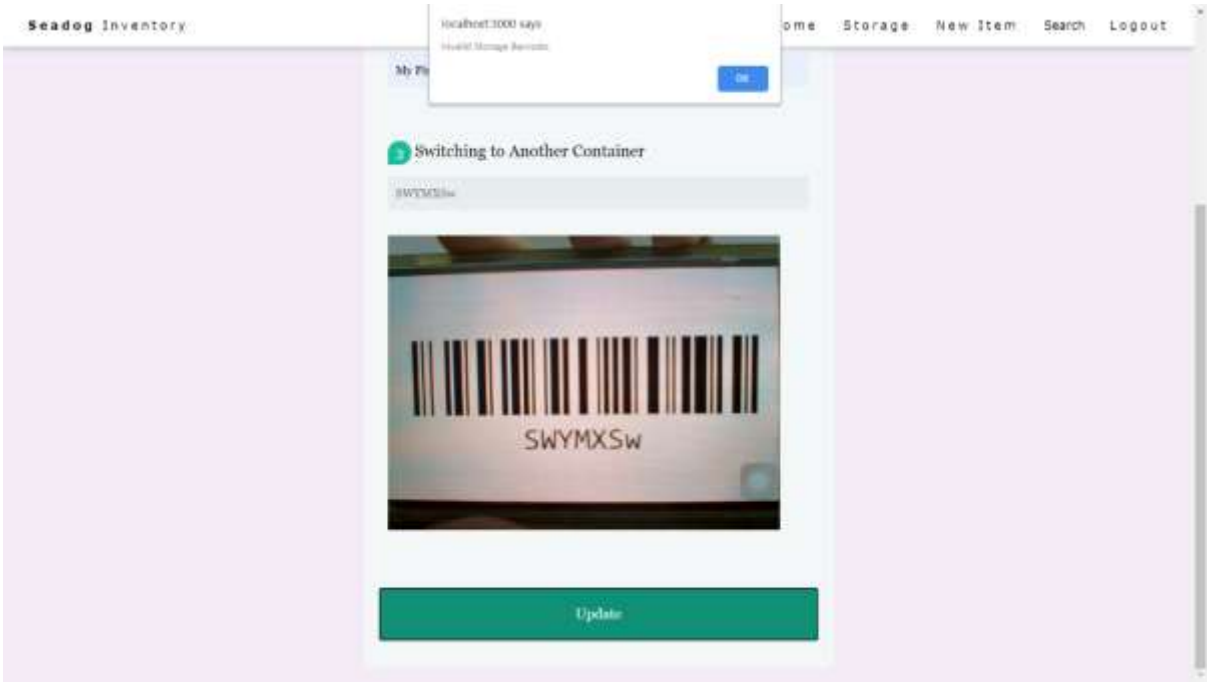

Figure 5.1.16 When the storage's barcode scanned is incorrect.

Product Checking

The user can choose to conduct product checking when he feels that there are something missing in the storage. The user needs to scan every items in the selected storage and can choose to end the checking when there is no item left to be scanned.

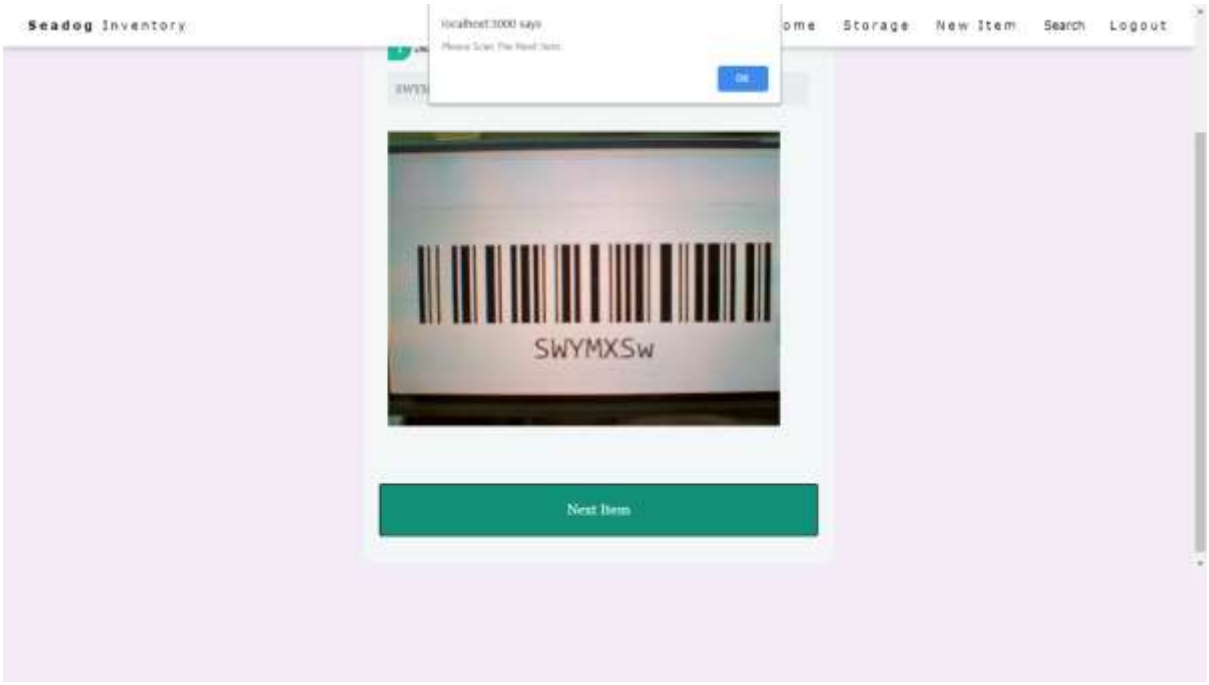

Figure 5.1.17 Product checking is started.

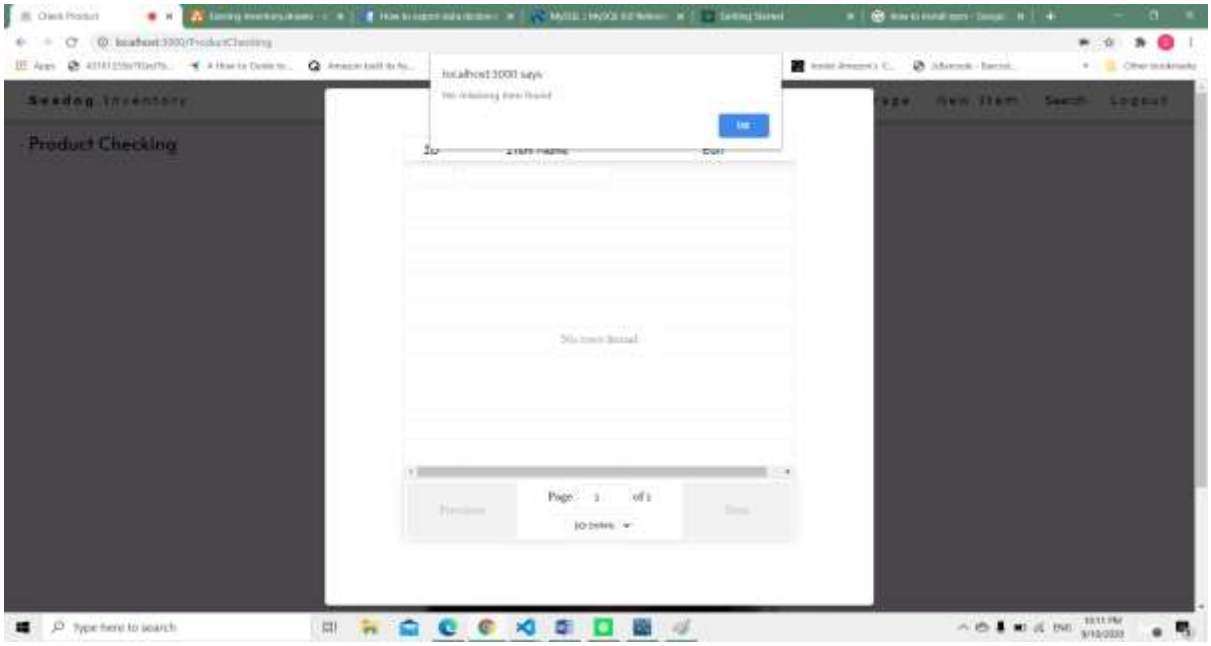

Figure 5.1.18 All the items in the storage are scanned.

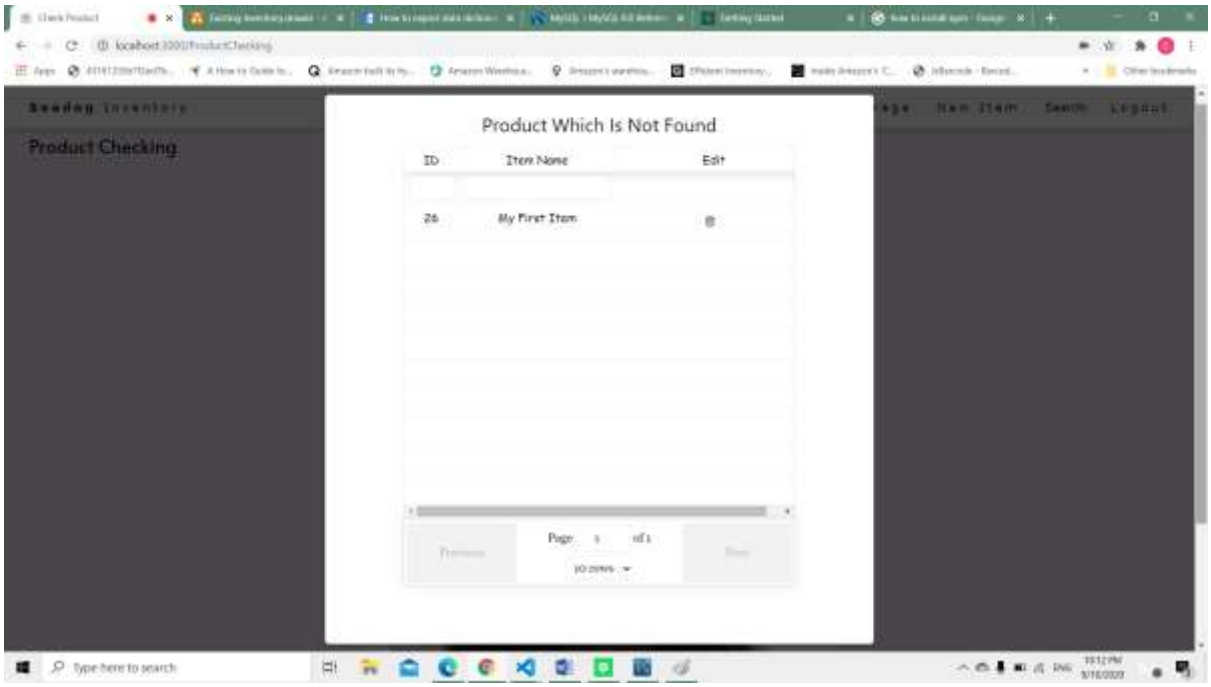

Figure 5.1.19 Item is counted not found when it is not scanned and user can choose to remove the items which are not found.

Check-In and Check-Out of Item

When the user wants to take out the item from the storage, he can perform check-out of the item in order to allow the system to temporarily remove it from the system. After the item is finished using, the user can put it back to any or previous storage by check-in the item. For check-out, the user only needs to scan the barcode of item that is being taken out. On the other hand, the user will need to scan the item's barcode and the storage that wants to place into when check-in.

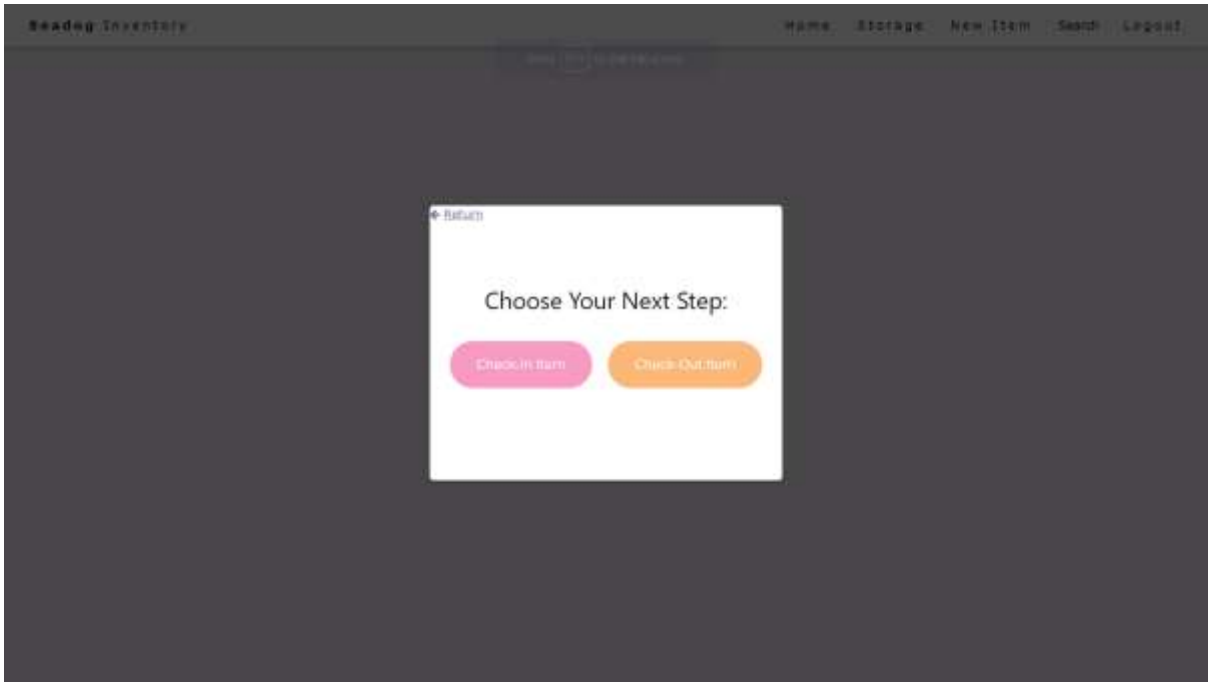

Figure 5.1.20 User can choose to put back or take out the item.

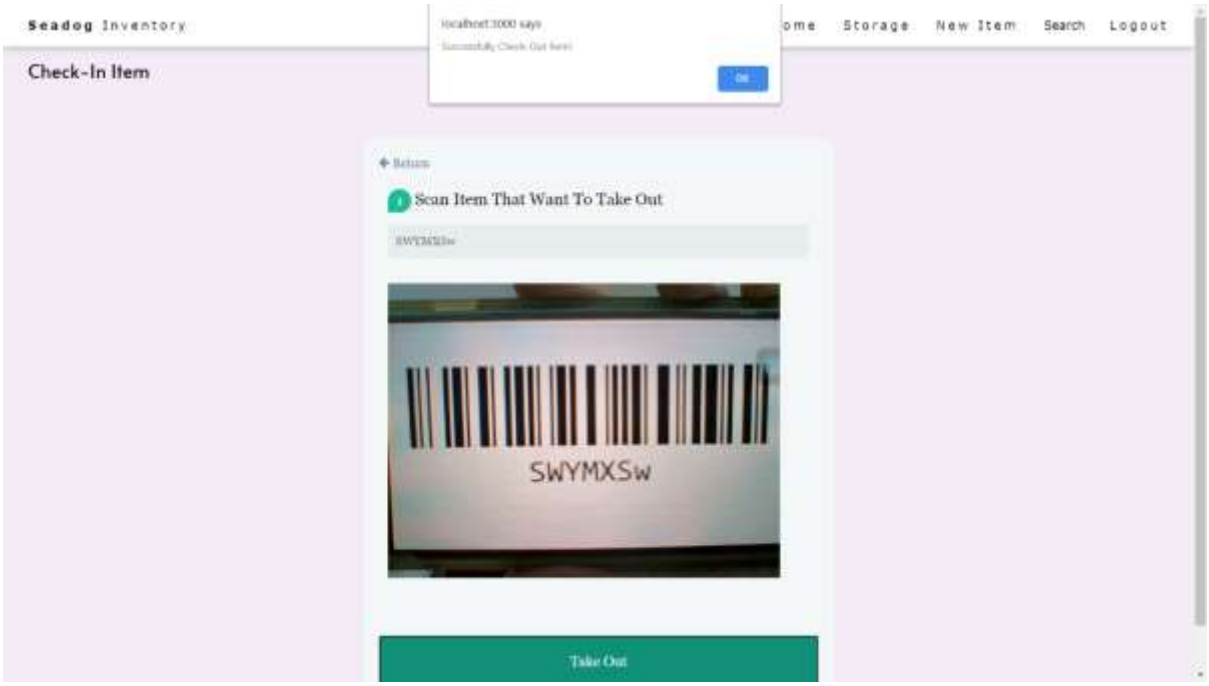

Figure 5.1.21 Item is checked-out.

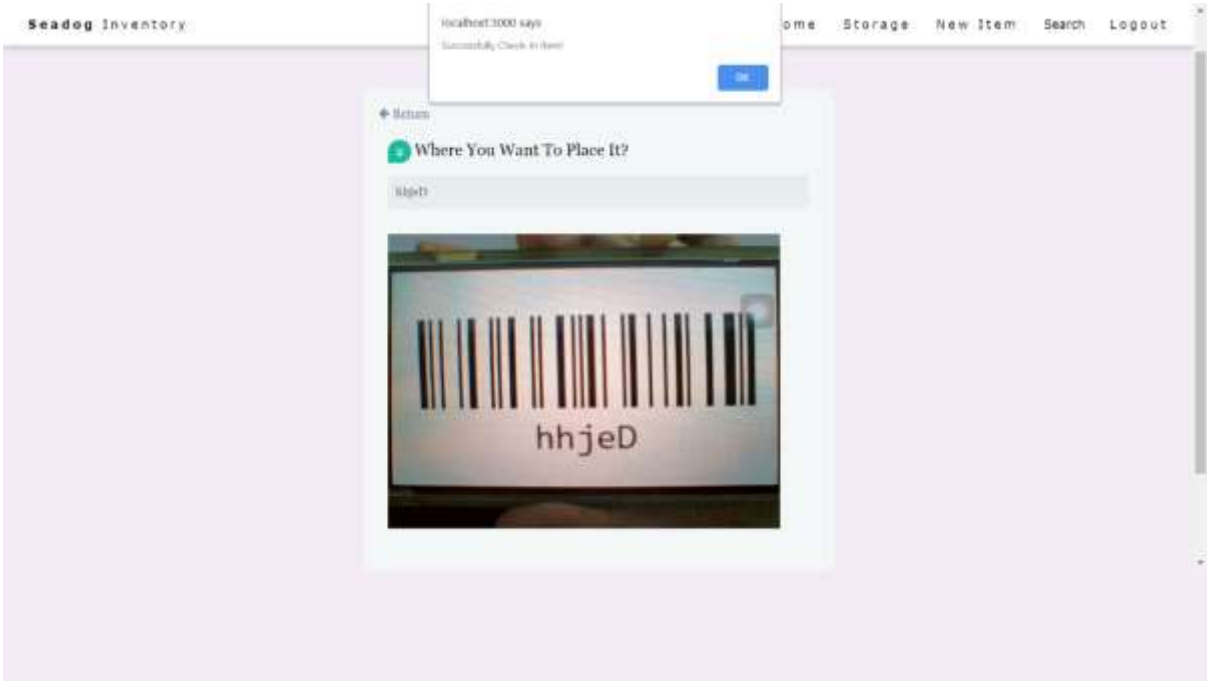

Figure 5.1.22 Item is checked-in.

Search for Storage

In this part, the user can identify the storage's information by scanning the barcode of the storage. This will direct user to the storage that is scanned.

Figure 5.1.23 Scan the storage that wanted to search.

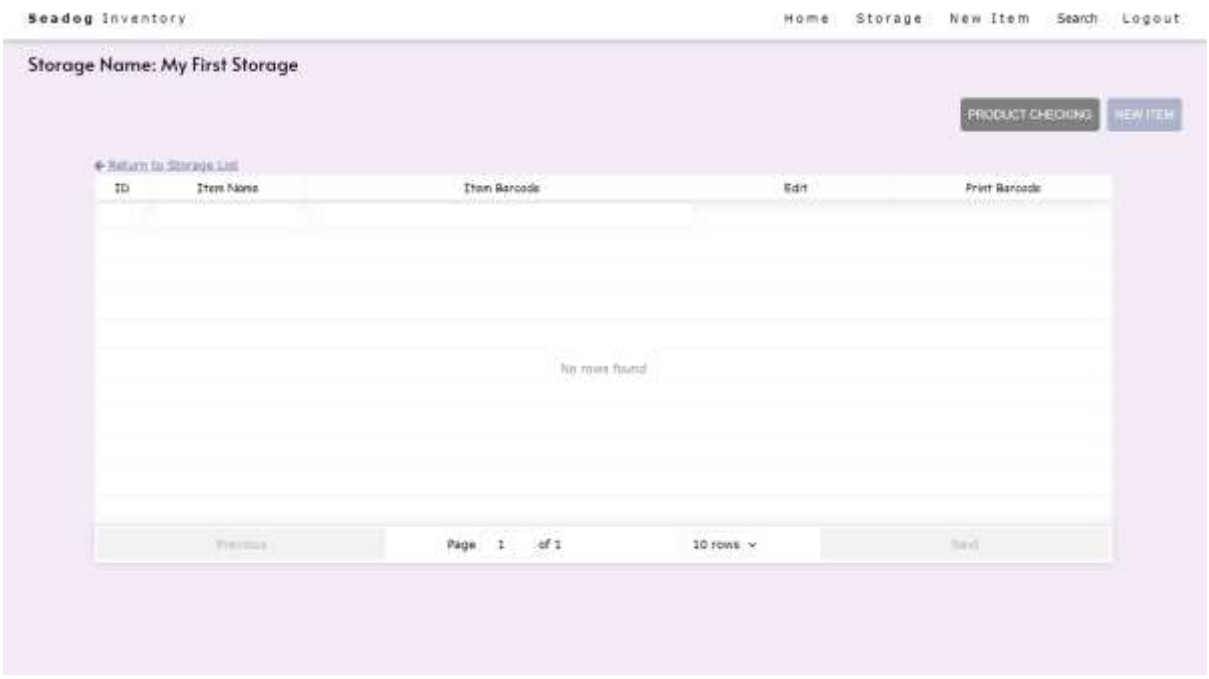

Figure 5.1.24 Redirect user to the scanned storage.

Search for Item

The barcode that are placed on the item might be dropped off or disappear. The user can retrieve back the item by applying the filter which is related to the item.

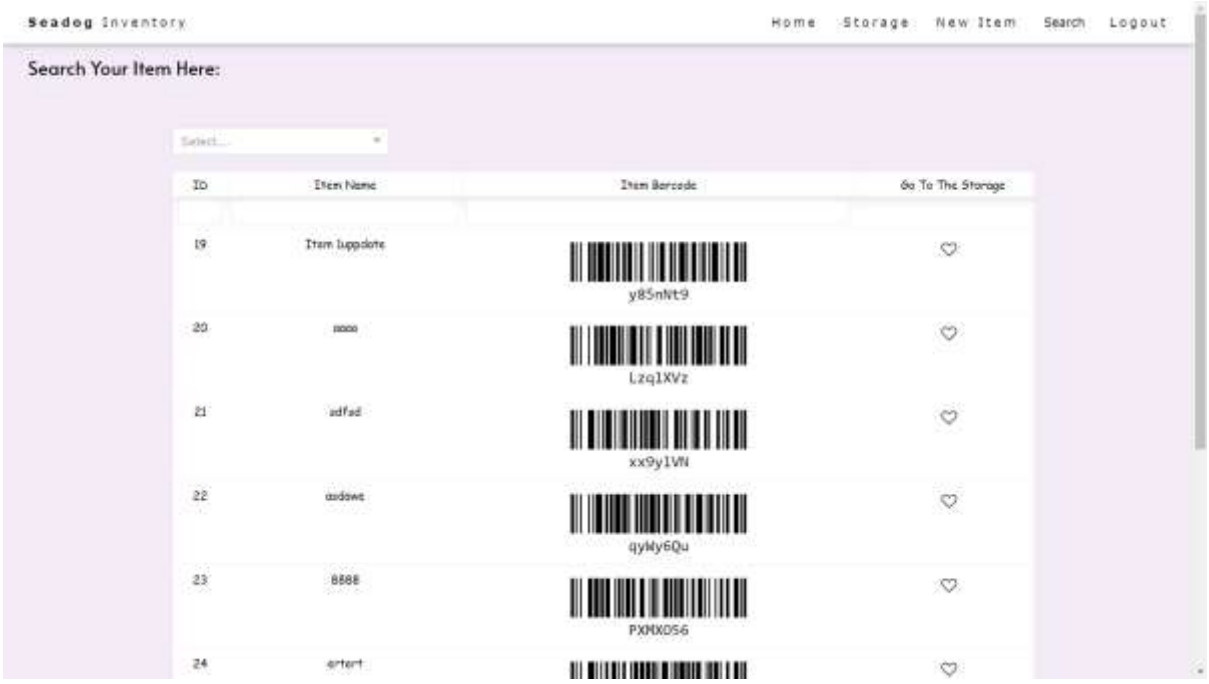

Figure 5.1.25 All the items are created by the user.

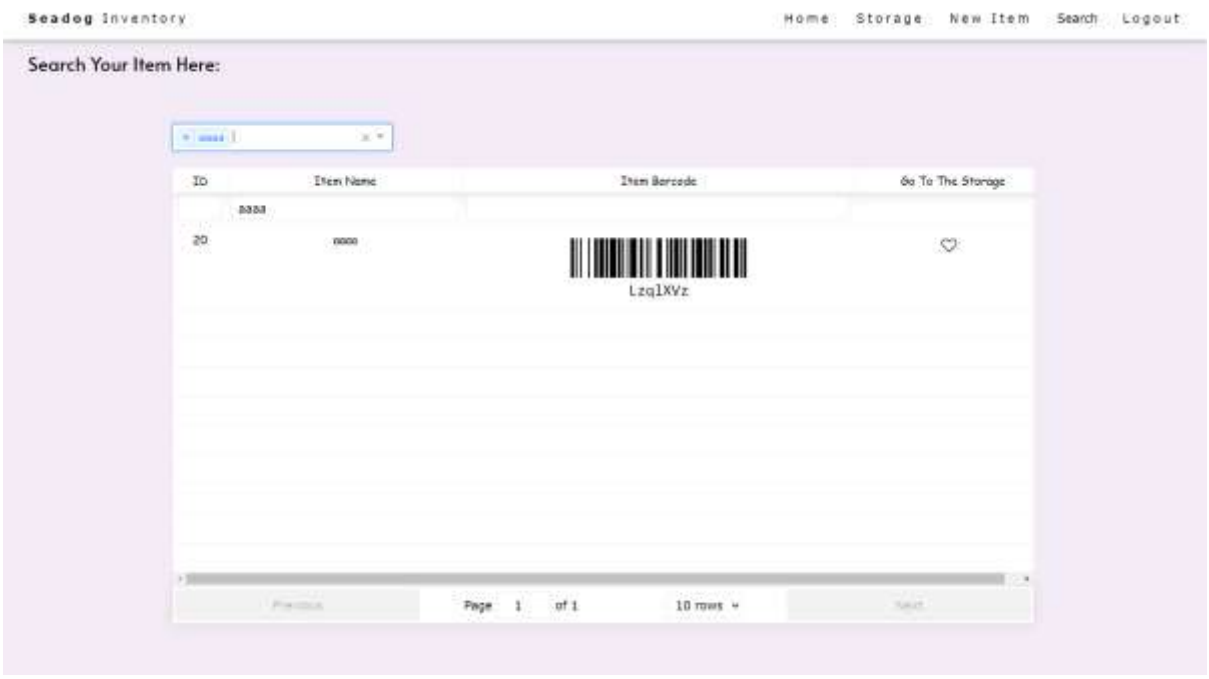

Figure 5.1.26 Apply the filter to search for the item.

Chapter 6: System Testing

User Login

Table 6.1 User Login Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	Login with a valid account username and valid password.	Login the user account with the correct username and correct password.	User can login to the system successfully.	The user able to access the system.	Y
2	Login with an invalid account username or invalid password or both invalid.	Login the user account with the incorrect username or incorrect password or both incorrect.	User cannot login to the system.	The user is not allowed to access the system and a pop-up message displaying "Invalid User" is shown.	Y
3	Login with both empty inputs.	Login the user account without filling out the username and passwords.	User cannot login to the system.	The user is not allowed to access the system and validation message will be shown under each inputs.	Y

User Register

Table 6.2 User Register Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	Register with an unique account username, valid password and unique email.	Register the user account with the correct username, correct password and correct email.	User can register successfully.	The user is able to sign up.	Y
2	Register with an invalid account username or invalid password or invalid email or all invalid.	Register the user account with the incorrect/used username or incorrect password or incorrect/used email or all incorrect.	User cannot register a new account.	The user is not able to sign up and a pop-up message displaying "Username or Email Is Used" is shown.	Y
3	Register with all empty inputs.	Register the user account without filling out the username, passwords and email.	User cannot register a new account.	The user is not able to sign up and validation error message will be shown below the inputs.	Y

Create Storage

Table 6.3 Create Storage Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	Create a storage with unique storage name.	Create a storage by entering valid storage name.	User can create the storage successfully.	The storage is created successfully and success message will be pop-up.	Y
2	Create a storage with an invalid storage name.	Create a storage by entering invalid/used storage name.	User cannot create the storage.	The storage is not created and a message will be shown “Storage Name Is Used”.	Y
3	Create a storage with empty storage name.	Create a storage by entering empty storage name.	User cannot create the storage.	The storage is not created and validation error is shown below the input.	Y

Delete Storage

Table 6.4 Delete Storage Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	Delete the selected storage.	Delete the storage by pointing to the row of the storage.	User can delete the storage successfully.	The storage is deleted successfully and success message will be pop-up.	Y

Print Storage Barcode

Table 6.5 Print Storage Barcode Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	Print barcode of the selected storage.	Print the storage's barcode by pointing to the row of the storage.	User can print the storage's barcode successfully.	The storage's barcode is printed successfully.	Y

View Storage

Table 6.6 View Storage Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	View the selected storage with created items in it.	View the item inside the storage by pointing to the row of the storage.	User can view the item list in the selected storage.	The storage retrieved the item list successfully.	Y
2	View the selected storage without items in it.	View the empty storage by pointing to the row of the storage.	User can view the empty item list in the selected storage.	The storage is retrieved successfully with a pop-up message displaying "No item yet! Add one now".	Y

Add Item

Table 6.7 Add Item Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	Add item with valid item name.	Create the new item by entering the correct item name.	User can add the new item into the storage.	Item is created to the existing storage and a message "Item is created successfully" is shown.	Y
2	Add item with empty item name.	Create the new item without item name.	User cannot add the new item into the storage.	Item is not created and a validation message is shown below the input.	Y

Edit Item

Table 6.8 Edit Item Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	Edit item with valid item name and valid storage barcode.	Update the item info with valid item name and valid storage barcode.	The item info is update successfully.	Item is updated successfully and a pop-up message "Item is updated" is shown.	Y
2	Edit item with empty item name or empty storage's barcode or both empty.	Update the item info without filling out both inputs.	The item info cannot be updated.	Item is not updated successfully and validation message is shown below the input.	Y
3	Edit item with invalid storage's barcode.	Update the item info with incorrect	The item info cannot be updated.	Item is not updated successfully and a pop-up message	Y

		storage's barcode.		"Invalid Storage Barcode" is shown.	

Product Checking

Table 6.9 Product Checking Testing Table.

No.	Testing Method	Action Done	Expected Result	Actual Result	Meet Expectation (Y/N)
1	Check all the items in the storage.	Scan every item's barcode in the storage.	Product checking is completed successfully.	The system shows that the product checking is completed by displaying a pop-up message with "No item missing".	Y
2	Does not check all the items in the storage.	Does not scan every item's barcode in the storage.	Product checking is not completed successfully.	The system shows that the product checking is incomplete by displaying the list of item that are not found.	Y
3	Check the items with invalid item's barcode.	Scan the item info with incorrect item's barcode.	Product checking is not completed successfully.	Product checking is incomplete and a pop-up message "Invalid Item Barcode" is shown.	Y

Chapter 7: Conclusion

7.1 Project Review, Discussions and Conclusions

The problem statements for this project are mentioned earlier in Chapter 1.1. The first problem statement which is the excessive use of bins or containers are solved by using dynamic slotting for this inventory system. The user can easily find out the location of items even though they are not categorized. The user also can keep all different items might in the same container. The barcode that created using this inventory web app can be used to recognize the item exact location (keeps in which container). Next, the user used up a lot of time in searching the item by looking it from each container. By using this inventory system, the user able to visualize each container and find out the item. The user can scan the barcode on the container to view what is inside it. Besides, the user is unaware of the items that might be missing from the container. The user can conduct product checking by scanning each item from the container and does not have to go through all the storage records.

For other similar inventory system, they will conduct static storing as the items are all categorized and place according to their types. This method does not fully utilize all the spaces of the container. The more types of items that user wanted to store, the more container has to be used which may cause the physical storage is used up. Besides, this system use barcode to track every item and container which provides better visualization for users to save their time. This inventory system is a web application that has simple user interface which only requires user to carry out a few simple steps like clicking the button for decision making and scanning the barcode for different situations.

7.2 Future Work

In future, this inventory system can be improved with the feature of item trade market. The users of this system are connected to each other and they can share their items. They can communicate in between and can request to trade from the others. When the user is short of items, he can trade or buy from users which are nearby. The user will need to post his trade item to the system and the post can be view by other users. The users also can share their interests and hobby with each other and the users able to get the items they wanted without going to the shops.

Furthermore, this inventory system can include the quantity for the same items. For the similar items, the barcode can be generated with a few same characters. For an example, a normal cable and Cable B. The barcode used by the cable is "CABLE1" while the barcode used by the Cable B is "CABLE1B". Therefore, the cable has the quantity of two. This enables the searching of items can be faster and users also able to identify the similar items.

Last but not least, the quality of system also can be improved by adding the notification feature. This notification feature is used to remind users that the item is low in stock and suggest them to restock the items. Besides, the notification function also can be used to estimate the quantity of items that can be placed in the storage. The system will notify the user when the storage is almost full or too full. Then, the user will change a new or add a new storage to store the items.

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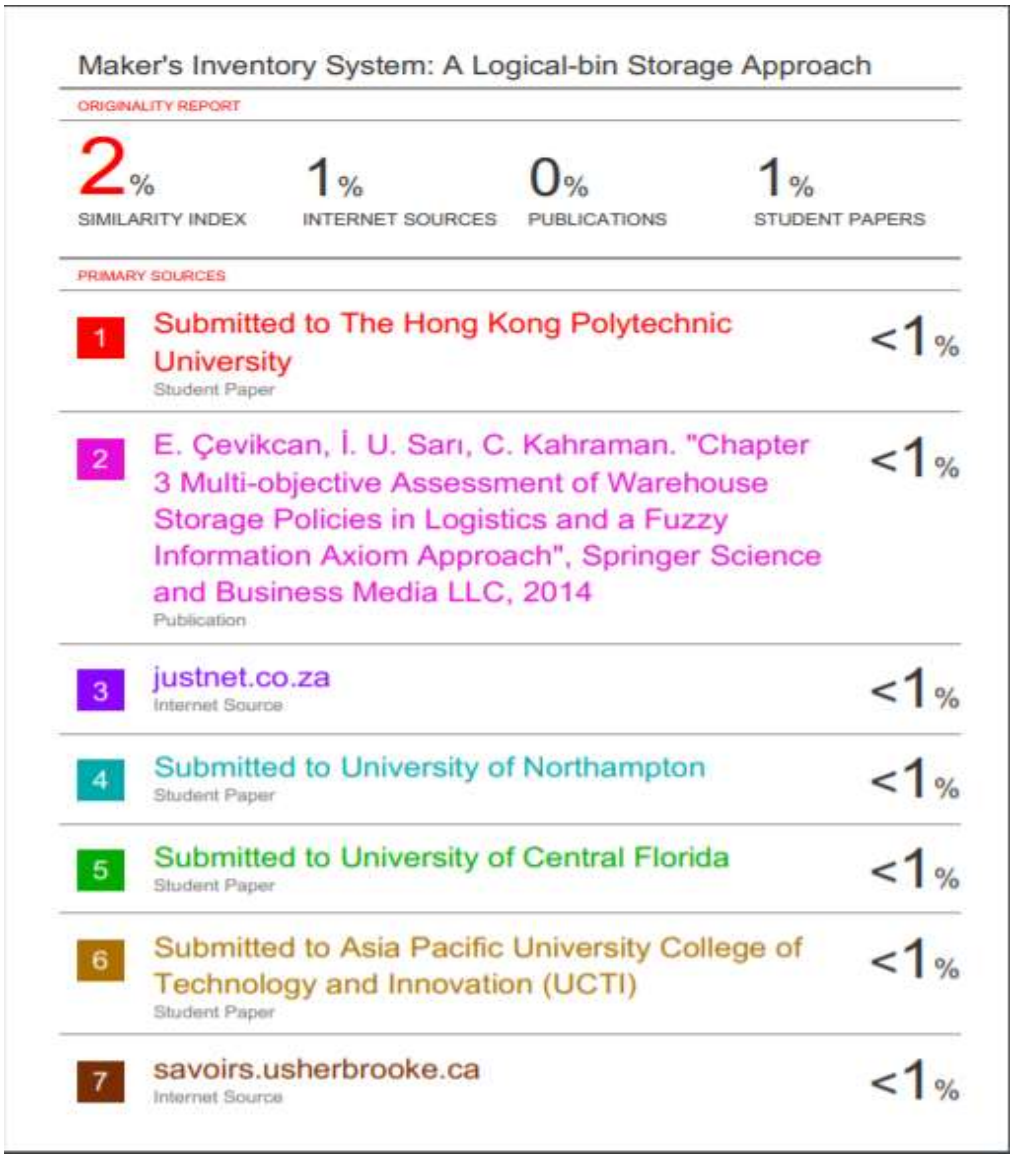
Appendix A: Plagiarism Check

Turnitin Report



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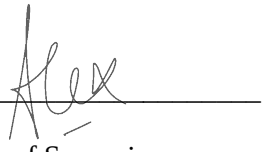

Signature of Supervisor

Name: Dr. Ooi Boon Yaik

Date: 11-Sep-2020

Signature of Co-Supervisor

Name: _____

Date: _____

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