PROJECT BCI 1093 DATA STRUCTURE & ALGORITHMS

TITLE: WAREHOUSE MANAGEMENT SYSTEM

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Case study

Case Study 1

Firstly, what is warehouse management really? According to Abby Jenkins (product marketing manager), warehouse management encompasses the principles and processes involved in running the day-to-day operations of a warehouse. At a high level, this includes receiving and organizing warehouse space, scheduling labor, managing inventory and fulfilling orders.

However, there are few common terms on warehouse management. For example, the terms inventory management, warehouse management and Stock Management are often used interchangeably. To understand them, explanation as below:

1. Inventory management

   Inventory Management is centered on efficiently and effectively ordering, storing, moving, and picking the materials needed to make products or fulfill orders.

2. Warehouse management

   Warehouse Management is a broader term that includes other aspects of warehouse operations, such as warehouse organization and design, labor, order fulfillment, warehouse monitoring and reporting.

3. Stock Management

   Stock generally refers to finished products ready for sale or distribution. Inventory, however, includes everything in the warehouse: raw materials, materials that are in the process of being built into products and finished products (stock).

   Stock management is therefore a subset of inventory management that focuses specifically on holding as little stock as possible—to save space and costs—while still being able to meet customer demand.

Next, the next thing we will see is warehouse management processes. To illustrate them more visually, explanation as below:

Receiving. Check in and log incoming items. Verify that you're receiving the right quantity, in the right condition, at the right time.

1. **Put-away.** Move items from the receiving dock to their correct storage locations.

2. **Storage.** Safely store and logically arrange inventory to enable fast and accurate picking.

3. **Picking.** Collect the items needed to fulfill sales orders.

4. **Packing.** Prepare the picked items for shipment. They must be safely packed into the correct packaging with an accurate packing slip.

5. **Shipping.** Send out the finalized sales orders, ensuring that they are on the right vehicle, at the right time, with the correct documentation, so customers receive their orders on time.

Beside, there are few strategies that will optimize warehouse management. There are:

§ Batch picking is a technique that can help you quickly fulfill multiple orders for the same product without wasting time by continually revisiting the same inventory location.

§ Zone picking assigns pickers to different zones of SKUs. For each order, pickers are responsible for picking all SKUs from their designated zone.

§ First expired, first out (FEFO) picking ensures perishable products and items make it to customers before specified expiration or sell-by dates. With FEFO, the products set to expire first are shipped first.

§ First in, first out (FIFO) picking ensures the first products to come into the warehouse are the first to be distributed, which can help make sure older items are shipped before they can become obsolete.

From the explanation above, First in, first out (FIFO) will be emphasized and used in this project to apply queue concept.

From: https://www.netsuite.com/portal/resource/articles/erp/warehouse-management.shtml

Case Study 2

Case study 2 will emphasize on warehouse management system of supermarket chains. This is because our project will emphasize on supermarket chains or something similar to it.

What can we take note on this case study is application using the Java/J2EE platform that deals with the flow of retail goods from suppliers to a warehouse, management of items within the warehouse and flow of items from the warehouse to the stores/shops from Q3 technologies.

The prominent features of the application are as described below:

1. **Movement of Items**: The application keeps track of the to and from movement of items from the warehouse and takes care of carriers and containers data, which are used to move goods within warehouse and store.

2. **Tracking of Defective Goods:** The application also keeps a track of all those goods that have been sent/returned back by the shops to the dispatched warehouse, as the delivered goods to them were defective.

3. **Inventory Replenishment from Other Linked Warehouses:** In case of unavailability of items in a warehouse, the application provides the information of other warehouses from where goods are available and can be dispatched.

4. Also, the application generates an anomaly, if any warehouse is not able to completely deliver the order/s to the shops. In this case, the application displays complete information, such as the warehouse details which were not able to deliver the goods, the reason behind the hindered activity, and check the availability of undelivered goods in another warehouse.

5. **Inventory Verification Measures**: Real measures of each product are needed in order to correctly stock articles inside the warehouse facilities. People who work in the warehouses have to verify the measures of each product. The application gives information about the measures that had been verified by the warehouse workers.

From:https://www.q3tech.com/wp-content/uploads/2020/10/Logistics-&-warehouse-management-system-for-a-large-Italian-supermarket-chain.pdf

Case Study 3

When it comes to case study 3, will there be more focus on how supermarkets control their inventory?

Based on the reference, the basis of inventory control is keeping a record of stock that comes into the store and stock that leaves the store. To summarize and visualize the process more easily and concise, explanation as below:

1. keeping a record of stock that comes into the store and stock that leaves the store.
2. Inventory that is kept in the supermarket warehouse, on the floor and in other areas of the store needs to be taken into account.
3. goods that are damaged, broken or used for display or other reasons also need to be accounted for.
4. bar coding, has made all of these issues much simpler to control.
5. New stock that arrives in the stockroom is simply loaded onto a computer according to its barcode.
6. When inventory leaves the stockroom, the information is entered into the computer.
7. Every time an item is sold, the information will be sent to a computer and the sale will be deducted from the inventory list.
8. In essence, the computer should, therefore, be able to tell you how much inventory there is of any one product.
9. It should also be able to tell you where it is in the store or stockroom at any given time and where it is located

Anyways. Since it will implicate the database, so 3 and 5 will be not involved in this project.

Assume that no goods will be damaged and return, and also there is no new stock arriving at the warehouse and stock replenishment occurs and ceteris paribus.

From: https://www.asp.com.au/how-does-supermarket-control-inventory/

Conclusion

In conclusion, supermarket inventory or supermarket chain warehouse system will be the core of this project. Take note that warehouse management system is a broad term, supermarket inventory is a subset of warehouse management. Therefore, supermarket inventory or supermarket chain warehouse systems will be fundamental for this project.

Organization of the code

Github link to source code: https://github.com/taimoon/DSAGroupProject
The readers may read the README file on github link for compilation details. The source code presented here might be outdated compared to github, so readers may refer to the git for the latest update. The source codes are included at the appendix.

The list of C source code files:

1. driver.c
2. warehouseSystem.h
3. Cir_List.h
4. C Dynamic Array.h
5. Sort Algorithm.h
6. builder.c
7. DataBackUp.c

The driver.c is the file where the menu is located. The warehouseSystem.h contains how requests and products are displayed,modified, and stored. Cir_List.h, C Dynamic Array.h, and Sort Algorithm.h provide the support of data structure, searching and sorting algorithms.

The builder.exe from compiling builder.c, acts like an installer to build the driver.exe from the driver.c, so please consider using it.

Lastly, the DataBackUp.c can be compiled into 2 exes which are retrieve and backup. The backup.exe is to back up the data of product and request, whereas the retrieve.exe is to retrieve back the data.

Cir_List.h

Cir_List.h is an library providing the implementation of the circular doubly linked list, with the definition goes like this

```
struct node{
    T val;
    struct node* next;
    struct node* back;
};
```

where T denotes any data types. User must define the T before including the library, for example from our project:

```
typedef struct request{
    unsigned int orderID;
    char receiver[RECEIVER_NAME_MAX_LEN];
    char direction;
    char requestDate[DATE_MAX_LEN];
    array requestList;
    float totalPrice;
    address target;
}request;
//request will be using the linked list
typedef request T;
#include "Cir_List.h"
```

In the warehouseSystem.h, we define the queue data structure from the Cir_List.h as below:

```
void enqueue(node** queue, request instance)
{
    pushBack(queue, instance);
}
request dequeue(node ** queue)
{
    return popFront(queue);
}
```

C Dynamic Array.h

C Dynamic Array.h is the implementation that mimics the C++ STL vector data structure. C Dynamic Array provides an automatic growable array which is better than array. It grows by 2 times when overflow is detected, and it shrinks when half of its length is not in use. It is superior to the linked list as it supports constant accessed time and contiguous memory space which is the requirement of binary search. The trade off is sometimes reallocation and reassignment happens when the array grows. It is estimated to be O(n) time, according to the The Algorithm Design Manual by Skiena 2ed. It is still worth the trade off considering it allows binary search.

The dynamic array is used to define the item list of each request. One can do the same as in the Cir_List.h to use the library for example in the project:

```
typedef struct product{
    char barcode[BARCODE_MAX_LEN];
    char name[PRODUCT_NAME_MAX_LEN];
    char category[CATEGORY_NAME_MAX_LEN];
    float price;
}product;
typedef struct RequestRow{
    product self;
    unsigned int qty;
}RequestRow;
//RequestRow will be using the dynamic array
typedef RequestRow ArrT;
#include "C Dynamic Array.h"
```

Sorting Algorithm.h

C Generic Binary Search: https://youtu.be/gezZlksnhU4
Though the video merely explains the binary search, it gives the idea of implementing other generic sorting algorithms in C.

The Sorting Algorithm.h provides at least 2 important functions which are **binary search** and **quick sort**.

```
int BinarySearch(const void* key, const void *arr,
                 size_t len, size_t elemSize,
                 int(*cmp)(const void*, const void*));
void QuickSort(void* arr, size_t len, size_t elemSize, int (*cmp)(const void*, const
void*));
```

Note that they required additional arguments compared to normal implementation. The additional arguments are comparator and the size of data.

In essence of how these work, it exploits the fact of contiguous property of the array which allows pointer arithmetic.

Below are examples of comparators from our project.

```
int ProductBarcodeComp(const void*  a, const void* b)
{
    return strcmp((*(product *)a).barcode, (*(product *)b).barcode);
}
int ProductNameComp(const void*  a, const void* b)
{
    return strcmp((*(product *)a).name, (*(product *)b).name);
}
int ProductCategoryComp(const void*  a, const void* b)
{
    return strcmp((*(product *)a).category, (*(product *)b).category);
}
int ProductPriceComp(const void*  a, const void* b)
{
    if((*(product *)a).price==(*(product *)b).price)
        return 0;
    else if((*(product *)a).price > (*(product *)b).price)
        return 1;
    else
        return -1;
}
```

Example of using binary search

```
input("Enter the barcode of product you wish to request: ", "%[^\n]s",&barcode);
int idx= BinarySearch(barcode, ProductList, len, sizeof(product), ProductBarcodeComp);
```

Example of using quick sort for struct data type

```
void SortedProduct(product *ProductList, int len)
{
    int UserInput = 0;
    printf("\nView sorted product List based on\n"
           "1)\t Barcode\n"
           "2)\t Name\n"
           "3)\t Category\n"
           "4)\t Price\n");
    input("Enter the number: ", "%d", &UserInput);
    switch(UserInput)
    {
    case 1:
        QuickSort(ProductList, len, sizeof(product), ProductBarcodeComp);
        break;
    case 2:
        QuickSort(ProductList, len, sizeof(product), ProductNameComp);
        break;
    case 3:
        QuickSort(ProductList, len, sizeof(product), ProductCategoryComp);
        break;
    case 4:
        QuickSort(ProductList, len, sizeof(product), ProductPriceComp);
        break;
    }
}
```

warehouseSystem.h

The warehouseSystem.h is the source code where displaying functions, data definition, modification functions and calculation functions are located.

Data Definition

```
#define BARCODE_MAX_LEN 16
#define PRODUCT_NAME_MAX_LEN 64
#define CATEGORY_NAME_MAX_LEN 32
#define RECEIVER_NAME_MAX_LEN 32
#define DATE_MAX_LEN 12
#define DETAILADDR_MAX_LEN 64
#define STREET_MAX_LEN 32
#define CITY_MAX_LEN 32
#define STATE_MAX_LEN 32
#define POSTCODE_MAX_LEN 16
#define OUTBOUND 0
#define INBOUND 1
typedef struct product{
    char barcode[BARCODE_MAX_LEN];
    char name[PRODUCT_NAME_MAX_LEN];
    char category[CATEGORY_NAME_MAX_LEN];
    float price;
}product;
typedef struct RequestRow{
    product self;
    unsigned int qty;
}RequestRow;
//RequestRow will be using the dynamic array
typedef RequestRow ArrT;
#include "C Dynamic Array.h"
//Note that the array here is the array of RequestRow Datatype
typedef struct address{
    char DetailAddr[DETAILADDR_MAX_LEN];
    char street[STREET_MAX_LEN];
    char city[CITY_MAX_LEN];
    char state[STATE_MAX_LEN];
    char postcode[POSTCODE_MAX_LEN];
}address;
typedef struct request{
    unsigned int orderID;
    char receiver[RECEIVER_NAME_MAX_LEN];
    char direction;
    char requestDate[DATE_MAX_LEN];
    array requestList;
    float totalPrice;
    address target;
}request;
//request will be using the linked list
typedef request T;
#include "Cir_List.h"
```

Program Output

Main menu:

The user is provided to navigate by inputting based on the display.
Any input other than shown will simply loop the prompt again.

```
WAREHOUSE SYSTEM MANAGEMENT
Enter the number to nagvigate
1)       View Product List
2)       View Request
3)       Add Product
4)       Edit and Delete Product
5)       Add Request
6)       Fulfil Request
q)       Quit
```

1) **View Product List:**

   The user is prompted for the way to sort the product list.
   Any input other than shown will simply loop the prompt again.

```
View sorted product List based on
1)       Barcode
2)       Name
3)       Category
4)       Price
Enter the number: 1
```

View sorted product list based on:

1) Product list is sorted based on **Barcode** in ascending order:

```
Enter the number: 1
No      Barcode         Product Name            Category        Price(RM)
1       4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
2       4987205947537           Bigen Speedy No 881     Beauty  13.50
3       6952695000145           Notebook Bar    Stationary      5.50
4       6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
5       80051671                Nutella 200g    Packaged Food   18.50
6       8850007032298           Johnson's Lotion        Medical Supplies        18.00
7       8888240000934           Super White Coffee      Packaged Food   1.80
8       9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
9       9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
10      9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
11      9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
12      9556231111110           Gardenia Classic        Packaged Food   2.90
13      9556439889521           Munchy's Lexus  Packaged Food   15.50
14      9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
15      9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
16      9780374533557           Thinking Fast and Slow  Book    55.30
17      teng teng teng          teng teng       te      12.00
```

2) Product list is sorted based on **Name** in ascending order:

```
Enter the number: 2
No      Barcode         Product Name            Category        Price(RM)
1       9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
2       9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
3       4987205947537           Bigen Speedy No 881     Beauty  13.50
4       9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
5       4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
6       9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
7       9556231111110           Gardenia Classic        Packaged Food   2.90
8       8850007032298           Johnson's Lotion        Medical Supplies        18.00
9       9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
10      9556439889521           Munchy's Lexus  Packaged Food   15.50
11      6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
12      6952695000145           Notebook Bar    Stationary      5.50
13      80051671                Nutella 200g    Packaged Food   18.50
14      8888240000934           Super White Coffee      Packaged Food   1.80
15      9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
16      9780374533557           Thinking Fast and Slow  Book    55.30
17      teng teng teng          teng teng       te      12.00
```

3) Product list is sorted based on **Category** in ascending order::

```
Enter the number: 3
No      Barcode         Product Name            Category        Price(RM)
1       4987205947537           Bigen Speedy No 881     Beauty  13.50
2       9780374533557           Thinking Fast and Slow  Book    55.30
3       9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
4       4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
5       6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
6       9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
7       9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
8       8850007032298           Johnson's Lotion        Medical Supplies        18.00
9       9556439889521           Munchy's Lexus  Packaged Food   15.50
10      9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
11      9556231111110           Gardenia Classic        Packaged Food   2.90
12      8888240000934           Super White Coffee      Packaged Food   1.80
13      80051671                Nutella 200g    Packaged Food   18.50
14      9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
15      6952695000145           Notebook Bar    Stationary      5.50
16      9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
17      teng teng teng          teng teng       te      12.00
```

4) Product list is sorted based on **Price** in ascending order:

```
Enter the number: 4
No      Barcode         Product Name            Category        Price(RM)
1       9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
2       9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
3       8888240000934           Super White Coffee      Packaged Food   1.80
4       9556231111110           Gardenia Classic        Packaged Food   2.90
5       9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
6       6952695000145           Notebook Bar    Stationary      5.50
7       6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
8       9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
9       teng teng teng          teng teng       te      12.00
10      9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
11      4987205947537           Bigen Speedy No 881     Beauty  13.50
12      9556439889521           Munchy's Lexus  Packaged Food   15.50
13      9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
14      8850007032298           Johnson's Lotion        Medical Supplies        18.00
15      80051671                Nutella 200g    Packaged Food   18.50
16      4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
17      9780374533557           Thinking Fast and Slow  Book    55.30
```

2) View Request:

The user is prompted for the direction of request.

```
Enter the direction of request(0=Outbound/1=INBOUND):
```

Direction of request:

1) Input “0” to list all the requests in order for **outbound**:

```
Enter the direction of request(0=Outbound/1=INBOUND): 0

1
The orderID of the request: 3645384359
The receiver name of the request: Reimu Hakuri
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       6971273211957   Non-Medical Disposable Mask     5.50    10
2       9557892101052   Analgesic Agent VOREN   8.80    100
Total Price: RM 935.00


2
The orderID of the request: 1012117674
The receiver name of the request: Kirisame Marisa
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       9780374533557   Thinking Fast and Slow  55.30   3
2       4891338037181   Darline Cup CN We Bare Bears    21.50   20
3       9556089422949   Faber Castell Ball Pen X7 4pcs  4.30    100
Total Price: RM 1025.90


3
The orderID of the request: 1012117678
The receiver name of the request: Izayoi Sakuya
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       8850007032298   Johnson's Lotion        18.00   10
2       8888240000934   Super White Coffee      1.80    250
3       9555187902193   The Store Mini Tissues Lavender 1.00    100
4       9556231111110   Gardenia Classic        2.90    20
5       9555070101283   Air Minuman Lucky Day   1.80    50
Total Price: RM 878.00
```

2) Input “1” to list all the requests in order for **inbound**:

```
Enter the direction of request(0=Outbound/1=INBOUND): 1

1
The orderID of the request: 999
The receiver name of the request: teng man
The direction of the product:OUTBOUND
The date of request: 111111
No      Product Name    Price   Qty
1       666679854       Chilling Ice    5.00    10
Total Price: RM 50.00


2
The orderID of the request: 789456
The receiver name of the request: pinky
The direction of the product:INBOUND
The date of request: 001100
No      Product Name    Price   Qty
1       789654123       SUPER WHITE COFFEE      1.20    12
2       7385400092      jaws playing card       5.60    77
Total Price: RM 445.60


3
The orderID of the request: 97654
The receiver name of the request: reimu
The direction of the product:INBOUND
The date of request: 240122
No      Product Name    Price   Qty
1       4891338037181   Darline Cup CN We Bare Bears    21.50   100
Total Price: RM 2150.00
```

3) Add Product

The user is prompted whether to continue input or stop.

```
Enter 1 to continue input, or 0 to stop
```

Example of input (after input “1”):

```
Enter 1 to continue input, or 0 to stop1
Enter the barcode of the product: 531055193055
Enter the name of the product: CALPIS Cultured Drink Original 350ml
Enter the category of the product: Packaged Food
Enter the price of the product: 2.00
Enter 1 to continue input, or 0 key to stop0
```

Updated product list:

```
No      Barcode         Product Name            Category        Price(RM)
1       4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
2       4987205947537           Bigen Speedy No 881     Beauty  13.50
3       531055193055            CALPIS Cultured Drink Original 350ml    Packaged Food   2.00
4       6952695000145           Notebook Bar    Stationary      5.50
5       6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
6       80051671                Nutella 200g    Packaged Food   18.50
7       8850007032298           Johnson's Lotion        Medical Supplies        18.00
8       8888240000934           Super White Coffee      Packaged Food   1.80
9       9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
10      9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
11      9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
12      9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
13      9556231111110           Gardenia Classic        Packaged Food   2.90
14      9556439889521           Munchy's Lexus  Packaged Food   15.50
15      9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
16      9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
17      9780374533557           Thinking Fast and Slow  Book    55.30
18      teng teng teng          teng teng       te      12.00
```

(CALPIS Cultured Drink Original 350ml at no. 3 in View Product List from the main menu)

4) Edit and Delete Product

The user is prompted to view sorted product list so they can choose the number of the product in the list to edit or delete.

```
View sorted product List based on
1)       Barcode
2)       Name
3)       Category
4)       Price
Enter the number: 1
No      Barcode         Product Name            Category        Price(RM)
1       4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
2       4987205947537           Bigen Speedy No 881     Beauty  13.50
3       531055193055            CALPIS Cultured Drink Original 350ml    Packaged Food   2.00
4       6952695000145           Notebook Bar    Stationary      5.50
5       6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
6       80051671                Nutella 200g    Packaged Food   18.50
7       8850007032298           Johnson's Lotion        Medical Supplies        18.00
8       8888240000934           Super White Coffee      Packaged Food   1.80
9       9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
10      9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
11      9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
12      9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
13      9556231111110           Gardenia Classic        Packaged Food   2.90
14      9556439889521           Munchy's Lexus  Packaged Food   15.50
15      9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
16      9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
17      9780374533557           Thinking Fast and Slow  Book    55.30
18      teng teng teng          teng teng       te      12.00
```

```
Input the number of the product:
```

After choosing the number of the product, you can choose to edit or delete it, or quit.

1) Input “d” to **delete** the chosen product:

```
Input the number of the product:18
Barcode: teng teng teng
Product: teng teng
Category: te
Price: 12.00

e)      Edit
d)      Delete
q)      Quit
d
```

(Chose the dummy product in the list to delete)

Updated product list:

```
No      Barcode         Product Name            Category        Price(RM)
1       4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
2       4987205947537           Bigen Speedy No 881     Beauty  13.50
3       531055193055            CALPIS Cultured Drink Original 350ml    Packaged Food   2.00
4       6952695000145           Notebook Bar    Stationary      5.50
5       6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
6       80051671                Nutella 200g    Packaged Food   18.50
7       8850007032298           Johnson's Lotion        Medical Supplies        18.00
8       8888240000934           Super White Coffee      Packaged Food   1.80
9       9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
10      9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
11      9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
12      9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
13      9556231111110           Gardenia Classic        Packaged Food   2.90
14      9556439889521           Munchy's Lexus  Packaged Food   15.50
15      9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
16      9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
17      9780374533557           Thinking Fast and Slow  Book    55.30
```

(Dummy product is no longer in the list)

2) Input “e” to **edit** the chosen product:

```
Input the number of the product:3
Barcode: 531055193055
Product: CALPIS Cultured Drink Original 350ml
Category: Packaged Food
Price: 2.00

e)      Edit
d)      Delete
q)      Quit
e
Enter the change if you wish, otherwise left it blank
Enter the barcode of the product:
Enter the name of the product:
Enter the category of the product:
Enter the price of the product(enter -1 if you're not intended to change): 2.20
```

(Chose the CALPIS product to update the price to 2.20)

Updated product list:

```
No      Barcode         Product Name            Category        Price(RM)
1       4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
2       4987205947537           Bigen Speedy No 881     Beauty  13.50
3       531055193055            CALPIS Cultured Drink Original 350ml    Packaged Food   2.20
4       6952695000145           Notebook Bar    Stationary      5.50
5       6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
6       80051671                Nutella 200g    Packaged Food   18.50
7       8850007032298           Johnson's Lotion        Medical Supplies        18.00
8       8888240000934           Super White Coffee      Packaged Food   1.80
9       9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
10      9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
11      9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
12      9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
13      9556231111110           Gardenia Classic        Packaged Food   2.90
14      9556439889521           Munchy's Lexus  Packaged Food   15.50
15      9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
16      9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
17      9780374533557           Thinking Fast and Slow  Book    55.30
```

(CALPIS Cultured Drink Original 350ml at no. 3 in updated with price 2.20)

5) Add request

The user is prompted for the direction of request to add.

```
Enter the direction of request(0=Outbound/1=INBOUND):
```

The user is prompt for the details of the request (orderID, receiver name and date of request)

```
Enter the orderID of the request: 523220203
Enter the receiver name of the request: Khai
Enter the date of request(DD/MM/YY): 020222
```

Product list will display for the user to enter the barcode of the product they want to request.

```
No      Barcode         Product Name            Category        Price(RM)
1       4891338037181           Darline Cup CN We Bare Bears    Household Supplies      21.50
2       4987205947537           Bigen Speedy No 881     Beauty  13.50
3       531055193055            CALPIS Culture Drink Original 350ml     Packaged Food   2.20
4       6952695000145           Notebook Bar    Stationary      5.50
5       6971273211957           Non-Medical Disposable Mask     Household supplies      5.50
6       80051671                Nutella 200g    Packaged Food   18.50
7       8850007032298           Johnson's Lotion        Medical Supplies        18.00
8       8888240000934           Super White Coffee      Packaged Food   1.80
9       9551012490002           COVID19 REAPID ANTIGEN TEST     Medical Supplies        15.50
10      9555070101283           Air Minuman Lucky Day   Packaged Food   1.80
11      9555187902193           The Store Mini Tissues Lavender Household Supplies      1.00
12      9556089422949           Faber Castell Ball Pen X7 4pcs  Stationary      4.30
13      9556231111110           Gardenia Classic        Packaged Food   2.90
14      9556439889521           Munchy's Lexus  Packaged Food   15.50
15      9556439893030           Munchy's LEXUS Salt Choco Biscuit Sandwich      Packaged Food   13.50
16      9557892101052           Analgesic Agent VOREN   Medical Supplies        8.80
17      9780374533557           Thinking Fast and Slow  Book    55.30
Enter the barcode of product you wish to request: 531055193055
```

The details of the product chosen is displayed, and user is prompt for the quantity.

```
Enter the barcode of product you wish to request: 531055193055
Barcode: 531055193055
Product: CALPIS Culture Drink Original 350ml
Category: Packaged Food
Price: 2.20
Enter the quantity: 5
Enter 1 if you wish to continue, or enter 0 to quit: 1
```

If the barcode does not exist in the list, it will display an error message.

```
Enter the barcode of product you wish to request: 2332
The barcode is not recorded in the system
```

The user may add more request under the same orderID.

6) Fulfil request

The user is prompted for the direction of request to fulfil.

```
Enter the direction of request(0=Outbound/1=INBOUND):
```

The request will be fulfilled based on the order of FIFO (First In, First Out), so the newest added request will be fulfilled last.

Example of chosen outbound:

```
Enter the direction of request(0=Outbound/1=INBOUND): 0
The orderID of the request: 3645384359
The receiver name of the request: Reimu Hakuri
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       6971273211957   Non-Medical Disposable Mask     5.50    10
2       9557892101052   Analgesic Agent VOREN   8.80    100
Total Price: RM 935.00
```

Outbound request list before fulfil:

```
Enter the direction of request(0=Outbound/1=INBOUND): 0

1
The orderID of the request: 3645384359
The receiver name of the request: Reimu Hakuri
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       6971273211957   Non-Medical Disposable Mask     5.50    10
2       9557892101052   Analgesic Agent VOREN   8.80    100
Total Price: RM 935.00


2
The orderID of the request: 1012117674
The receiver name of the request: Kirisame Marisa
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       9780374533557   Thinking Fast and Slow  55.30   3
2       4891338037181   Darline Cup CN We Bare Bears    21.50   20
3       9556089422949   Faber Castell Ball Pen X7 4pcs  4.30    100
Total Price: RM 1025.90


3
The orderID of the request: 1012117678
The receiver name of the request: Izayoi Sakuya
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       8850007032298   Johnson's Lotion        18.00   10
2       8888240000934   Super White Coffee      1.80    250
3       9555187902193   The Store Mini Tissues Lavender 1.00    100
4       9556231111110   Gardenia Classic        2.90    20
5       9555070101283   Air Minuman Lucky Day   1.80    50
Total Price: RM 878.00
```

Outbound request list after fulfil:

```
Enter the direction of request(0=Outbound/1=INBOUND): 0

1
The orderID of the request: 1012117674
The receiver name of the request: Kirisame Marisa
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       9780374533557   Thinking Fast and Slow  55.30   3
2       4891338037181   Darline Cup CN We Bare Bears    21.50   20
3       9556089422949   Faber Castell Ball Pen X7 4pcs  4.30    100
Total Price: RM 1025.90


2
The orderID of the request: 1012117678
The receiver name of the request: Izayoi Sakuya
The direction of the product:INBOUND
The date of request: 250122
No      Product Name    Price   Qty
1       8850007032298   Johnson's Lotion        18.00   10
2       8888240000934   Super White Coffee      1.80    250
3       9555187902193   The Store Mini Tissues Lavender 1.00    100
4       9556231111110   Gardenia Classic        2.90    20
5       9555070101283   Air Minuman Lucky Day   1.80    50
Total Price: RM 878.00
```

Reference

Books:
Introduction To Algorithm 3rd edition by Thomas H. Cormen and et al.
Note: Quick Sort pseudocode reference

The Algorithm Design Manual 2nd edition by Steven S. Skiena
Note: Dynamic Array, Linked List and Another Algorithm Reference

Internet:
https://www.geeksforgeeks.org/function-pointer-in-c/
Note: Function pointer for comparator

https://web.mit.edu/6.001/6.037/sicp.pdf
Structure and Interpretation of Computer Program Chapter 1
Note: For additional exercises and reference regarding the relevance and extension of function pointer(Functional Programming)

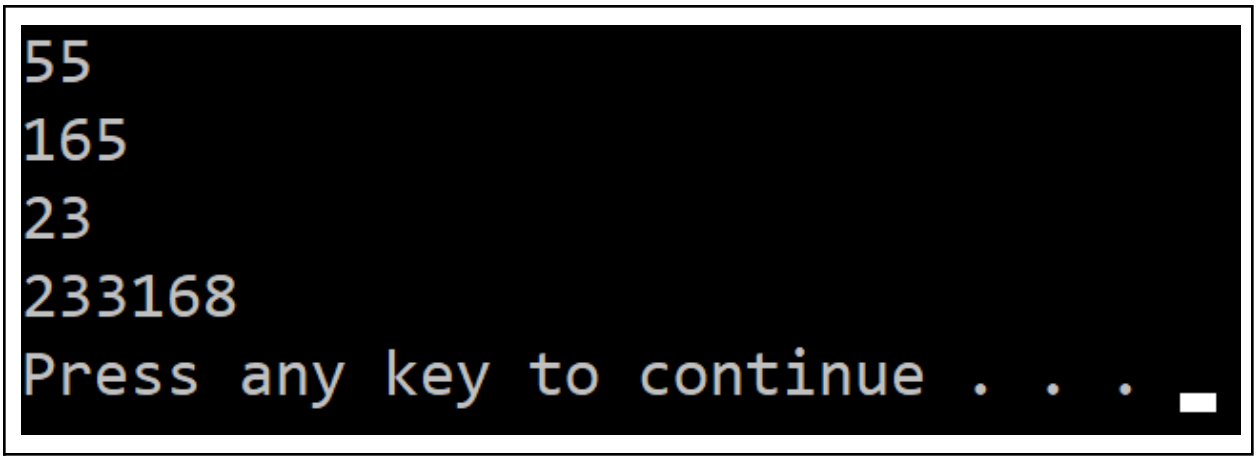
https://youtu.be/gezZlksnhU4
C Programming Tutorial 84, Generic Binary Search Algorithm
Note: Generic Binary Search which inspires us to implement generic sorting algorithm

C library reference:
https://www.cplusplus.com/reference/cstdlib/qsort/
https://www.cplusplus.com/reference/cstdlib/bsearch/
Note: Guide to define comparator for struct data type

Appendix

Function Pointer

```
#include<stdio.h>
#include<stdlib.h>
/*
<dataType> *<fuctionName> (args)
*/
//f(x_a)+f(x_{a+1})+...+f(x_b)
int summation(int (*f)(int), int start, int end){
    int sum = 0;
    for(int i = start; i <= end; ++i){
        sum = sum+f(i);
    }
    return sum;
}
int identity(int x){return x;}
int TripleFunc(int x){return 3*x;}
int FifthFunc(int x){return 5*x;}
int Func15(int x){return 15*x;}
int main(){
    printf("%d\n", summation(identity, 0, 10));
    printf("%d\n", summation(TripleFunc, 0, 10));
    printf("%d\n", summation(FifthFunc, 0, 9/5)+summation(TripleFunc, 0,
9/3));
    printf("%d\n", summation(FifthFunc, 0, 999/5)+summation(TripleFunc,
0, 999/3)-summation(Func15, 0, 999/15));
    system("PAUSE");
    return 0;
}
```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