Engineering Method

1.Identification of the problem:

A new game store needs a program that is able to organize their products so that customers can purchase and search different games in an effective way. In order to achieve this goal, the games have to be organized so that customers are able to find them easily and put them in their basket. In addition, the time of purchase has to be the most efficient, meaning the queue should take a few minutes.

2.The collection of the necessary information:

● The list of games is ordered according to the location of the shelves.
● A basket is assigned to place the games that the customer finds, one on top of the other, following the order supplied in the previous stage.
● The time in which the customer has entered the store, plus what has been taken collecting the games from each shelf is the order factor with which the row of bags(that contain games) are entered.
● The strategy in the packing section is: Customers make a single queue even if there are several ATMs or service points. When one or more service points are available, the first customer in the line proceeds to any service points as well as the following customers if more service points are available, in order to be attended one by one in each of them.
● Once the customer enters the store, he/she goes to section #1 of digital catalogs and successively goes to another 2 sections.
● Each customer takes about 1 unit of time to collect a game, therefore, the total time when leaving section 3 will be the previous value from section 2 plus the amount taken to collect the games.
● If two customers take the same time, the one that was before the exit of the previous section comes out first.
● The order in which the customer's games are packed is given taking into account the pile that the cashier has at his side. Whatever is at the top will obviously be the first to pack up and so on.

After having the information from the problem, we need the information from the complexity analysis for the different ordering methods to be able to choose 3 that are beneficial at the time of execution and time:

Source: https://pereiratechtalks.com/analisis-de-algoritmos-de-ordenamiento/

Bubble (Bubble Sort): Complexity O (n ^ 2)

This algorithm performs the ordering or reordering of a list a of n values, in this case of n terms numbered from 0 to n-1; It consists of two nested loops, one with the index i, which gives a smaller size to the path of the bubble in the reverse direction of 2 n, and a second loop with the index j, with a path from 0 to ni, for each iteration of the first loop, indicating the location of the bubble. The bubble is two terms in the list in a row, j and j + 1, which are compared: if the first is greater than the second, their values are exchanged. This comparison is repeated in the center of the two loops, resulting in an ordered list. It can be seen that the number of repetitions only depends on n and not on the order of the terms, that is, if we pass an already ordered list to the algorithm, it will perform all the comparisons exactly the same as for an unordered list.

Counting (Counting Sort): Complexity O (n + k)

It is a stable algorithm whose computational complexity is O (n + k), where n is the number of elements to be ordered and k is the size of the auxiliary vector (maximum - minimum). The efficiency of the algorithm is independent of how nearly ordered it was previously. In other words, there is no best and worst case, all cases are treated the same.The counting algorithm is not ordered in situ, but requires additional memory.

Heaps (Heapsort): Complexity O (n log n)
This algorithm consists of storing all the elements of the vector to be ordered in a heap (heap), and then extracting the node that remains as the root node of the heap (top) in successive iterations obtaining the ordered set. It bases its operation on a property of mounds, whereby the top always contains the smallest element (or the largest, depending on how the heap has been defined) of all those stored in it. The algorithm, after each extraction, relocates the last leaf to the right of the last level at the root or top node. Which destroys the heap property of the tree. But, then it carries out a process of "lowering" the number inserted so that the older of its two children is chosen at each movement, with whom it is exchanged. This exchange, carried out successively, "sinks" the node into the tree, restoring the tree's heap property and giving way to the next extraction of the root node.

Insertion (Insertion Sort): Complexity O (n ^ 2)
Initially you have only one element, which is obviously an ordered set. Then, when there are {\ displaystyle k} k elements ordered from least to greatest, the element {\ displaystyle k + 1} {\ displaystyle k + 1} is taken and compared with all the elements already ordered, stopping when a minor element (all major elements have been shifted one position to the right) or when no elements are found anymore (all elements were shifted and this is the smallest). At this point the element {\ displaystyle k + 1} {\ displaystyle k + 1} is inserted and the other elements must be moved.

Mixtures (Merge Sort): Complexity O (n log n)
If the length of the list is 0 or 1, then it is already sorted. In another case: Divide the unordered list into two sublists about half the size. Sort each sublist recursively applying the sort by mix. Mix the two sublists into a single ordered list. Merge sort incorporates two main ideas to improve your runtime: A small list will take fewer steps to sort than a large list. It takes fewer steps to build an ordered list from two ordered lists than from two unordered lists. For example, each list only needs to be interleaved once they are sorted.

Fast (Quicksort): Complexity O (n log n)
Choose an element from the set of elements to be ordered, which we will call a pivot. Relocate the other elements of the list on each side of the pivot, so that on one side are all those less than it, and on the other the greater ones. The elements equal to the pivot can be placed both to its right and to its left, depending on the desired implementation. At this point, the pivot occupies exactly its rightful place in the ordered list. The list is separated into two sub-lists, one formed by the elements to the left of the pivot, and the other by the elements to its right. Repeat this process recursively for each sublist as long as they contain more than one element. Once this process is finished, all the elements will be in order. As can be assumed, the efficiency of the algorithm depends on the position in which the chosen pivot ends. In the best case, the pivot ends up in the center of the list, dividing it into two sublists of equal size. In this case, the order of complexity of the algorithm is \ Omega (n · log n). In the worst case, the pivot ends up at one end of the list. The order of complexity of the algorithm is then O (n^2). The worst case will depend on the implementation of the algorithm, although it usually occurs in lists that are ordered, or almost ordered. But it mainly depends on the pivot, if for example the implemented algorithm always takes the first element of the array as a pivot, and the array that we pass to it is ordered, it will always generate an empty array on its left, which is inefficient.

Selection (Selection order): Complexity O (n ^ 2)
Find the smallest item in the list Trade it with the first Find the next minimum in the rest of the list Swap it with the second And in general: Find the minimum element between an i position and the end of the list Swap the minimum with the element at position

Source: https://medium.com/techwomenc/estructuras-de-datos-a29062de5483

LinkedList:
A list is that structure that represents a countable number of ordered values where the same value can be repeated and considered a different value from an existing one. The main characteristics of a list would be: Each node in our list contains one or more fields that contain the value we want to store. Each node contains at least one pointer field pointing to another node, which means that we can have 2 pointers, one that points to a consequent node and another that points to a previous node, thus forming a double linked list. It is necessary to have a pointer that points to the head of the structure in order to know where to start.

Stack:
A stack supports the ordered recovery of data last-in, first-out (LIFO) or: the last data to enter, the first data to leave.If we use a stack it is because probably the order of data retrieval does not matter so much to us, we simply want to stack and unstack them, so the fundamental operations in a stack are push and pop to put and get data from the stack.

Queue:
A queue or queue supports the orderly retrieval of data first-in, first-out (FIFO) or: the first data to enter is the first data to leave. In this type of structure, order does matter, since the first in the queue must always be the first to be attended and the rest wait their turn in an orderly manner. The operations of this structure are: enqueue and dequeue to queue and un-queue (put and get from the queue).

HashTable:
A Java Hashtable is a data structure that uses a hash function to identify data by means of a key or key. The hash function transforms a key to an index value of an array of elements.

3.The search for creative solutions:

● Implement a queue when organizing each customer's basket of games, in addition to implementing a stack to order the customer's queue when making payments and a HashTable to organize the shelves where the games will go for the ordering methods of the list of games we will use the following algorithms:

- ➔ Bubble sort
- ➔ Insertion sort

● Implement the three data structures as follows: HashTable for the different shelves, where games will be kept and in case they find collisions, they are solved with direct addressing, forming a linked list. Implement queues for customers when paying for their purchases, in addition to stacks when each customer picks up the game they are looking for. For the ordering methods of the list of games we will use the following algorithms:

- ➔ Bubble sort
- ➔ Insertion sort

● Implement queues for customers when paying for their purchases, in addition to stacks when each customer picks up the book they are looking for, and finally and for the shelves use HashTable with open addressing to fix collisions. For the ordering methods of the list of games we will use the following algorithms:

- ➔ Bubble sort
- ➔ Insertion sort

● Implement the three data structures as follows: HashTable for the different shelves, where books will be kept and in case they find collisions, they are solved with direct addressing, forming a linked list. Implement queues for customers when paying for their purchases, in addition to stacks when each customer picks up the book they are looking for For the ordering methods of the list of games we will use the following algorithms:

- ➔ Bubble sort
- ➔ Insertion sort

● Implement a binary tree to organize the basket of games for each customer, also implement a linked list to order the queue of customers when making payments and a stack to order the shelf. For the ordering methods of the list of games we will use the following algorithms:

- ➔ Bubble sort
- ➔ Insertion sort

Implementing the basket of games as trees could, however, we can only access the last added element (LIFO) so the most suitable for this basket of games would be the stack structure, as well as a list for customers can reach be inefficient since we do not need to access each customer, but we must access the first customer to enter the queue (FIFO), which is why the queue structure is more suitable for this function. As for the shelves, as we are going to save games by their code, the implementation of the hashtable helps us, since we can place the games according to their code in an array and solve the collisions with a link between the games. Therefore, the ideal structures are the following: STACK = Basket of games HashTable = Bookshelf Queue = Queue of customers. The other options are discarded, because although they may well solve the problem, they are not the most appropriate.

Sorting Algorithms:

- ➔ Insertion sort
- ➔ Bubble sort

Regarding the ordering algorithms, we decided to use these algorithms to organize the games, since in them we have efficient algorithms such as Insertion Sort and Bubble Sort () both O (n ^ 2).

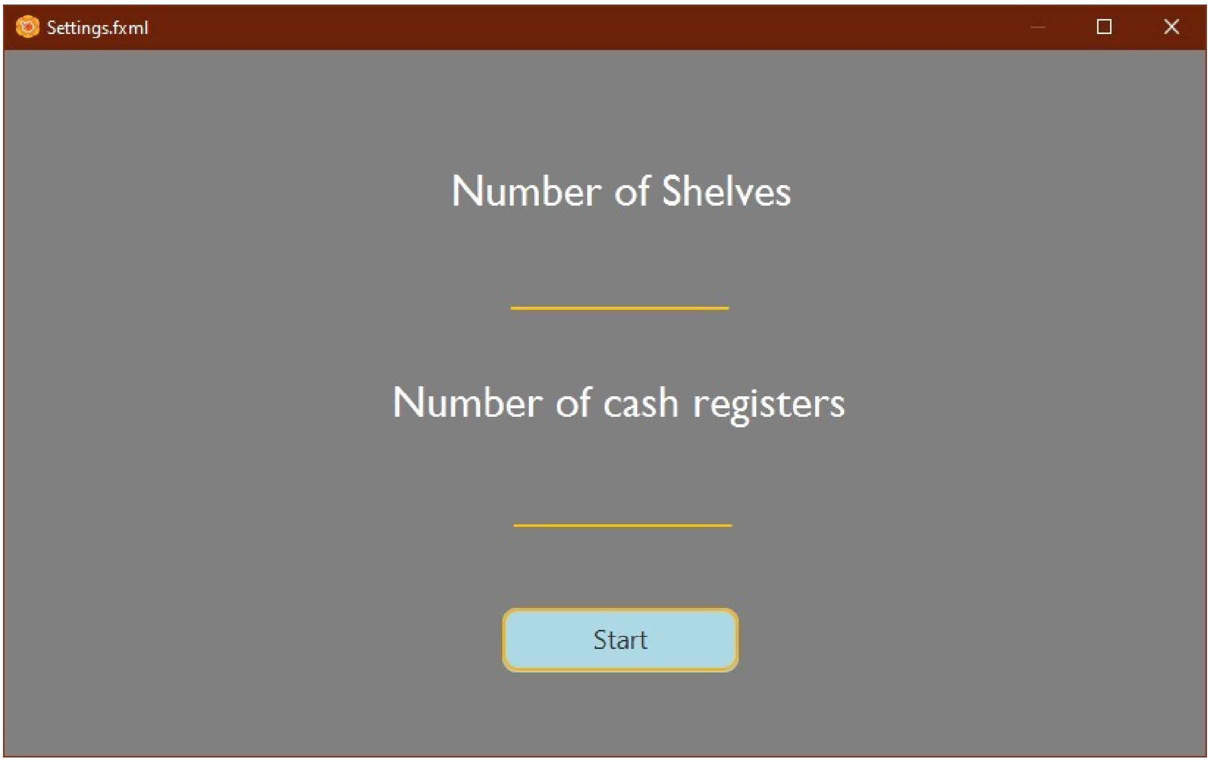
4.Moving from ideas to preliminary designs:
We consider that solutions 2 and 3 are the ones that most closely approximate the central idea of the problem and those that meet the initially proposed requirements.

Criterias:
Complexity: Each design and the methods that come with it present an appropriate difficulty for the development of it.
1. Medium
2. Easy Solution

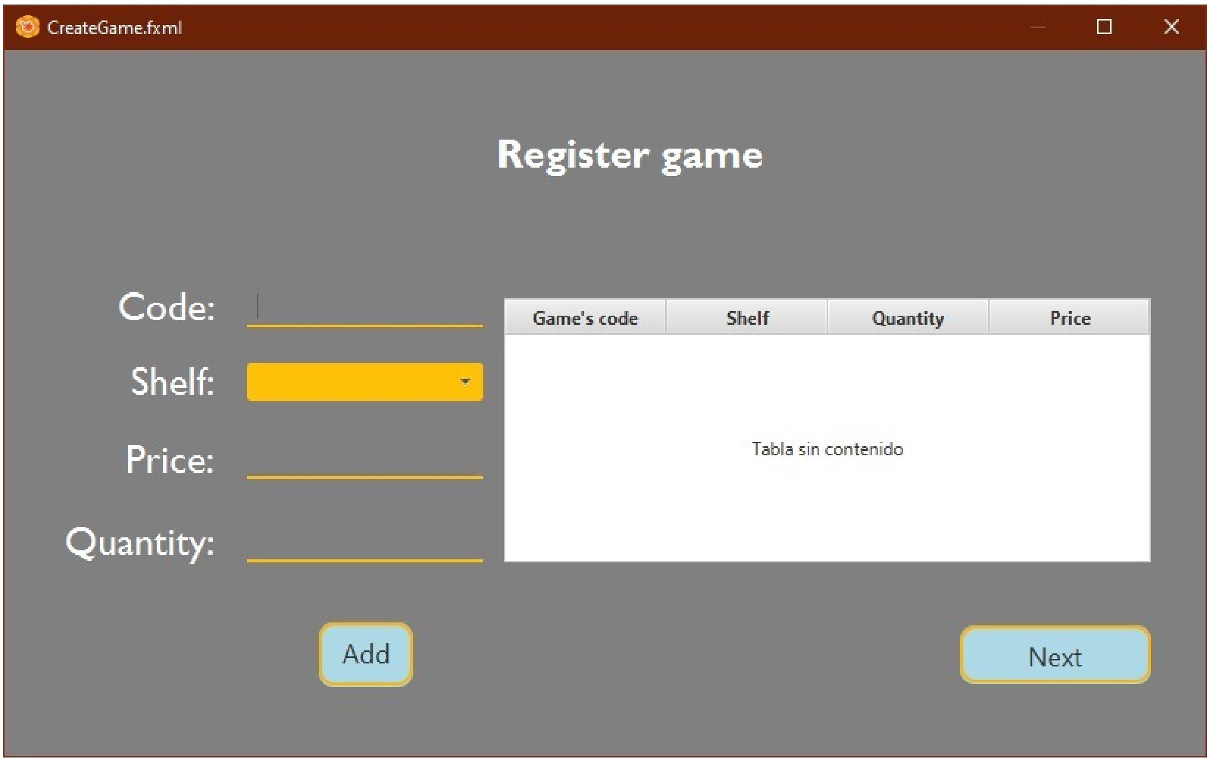
Precision: The solution is viable and meets the effective development of all the requirements of the problem
1. Almost Accurate
2. Accurate
Effectiveness: Regardless of the complexity, the solution complies with a perfect effectiveness lacking any logical error
1. Effective Medium
2. Effective
Usability: The solution can be used because it meets all the proposed objectives
1. Complex.
2. Usable

5.The evaluation and selection of the preferred solution:
Several data structures need to be implemented for the different problems and as mentioned above, queues for customers, stacks for game storage and linked list for game shelves will be implemented. In order to have fast and efficient data structures as well as the ordering of the structures.

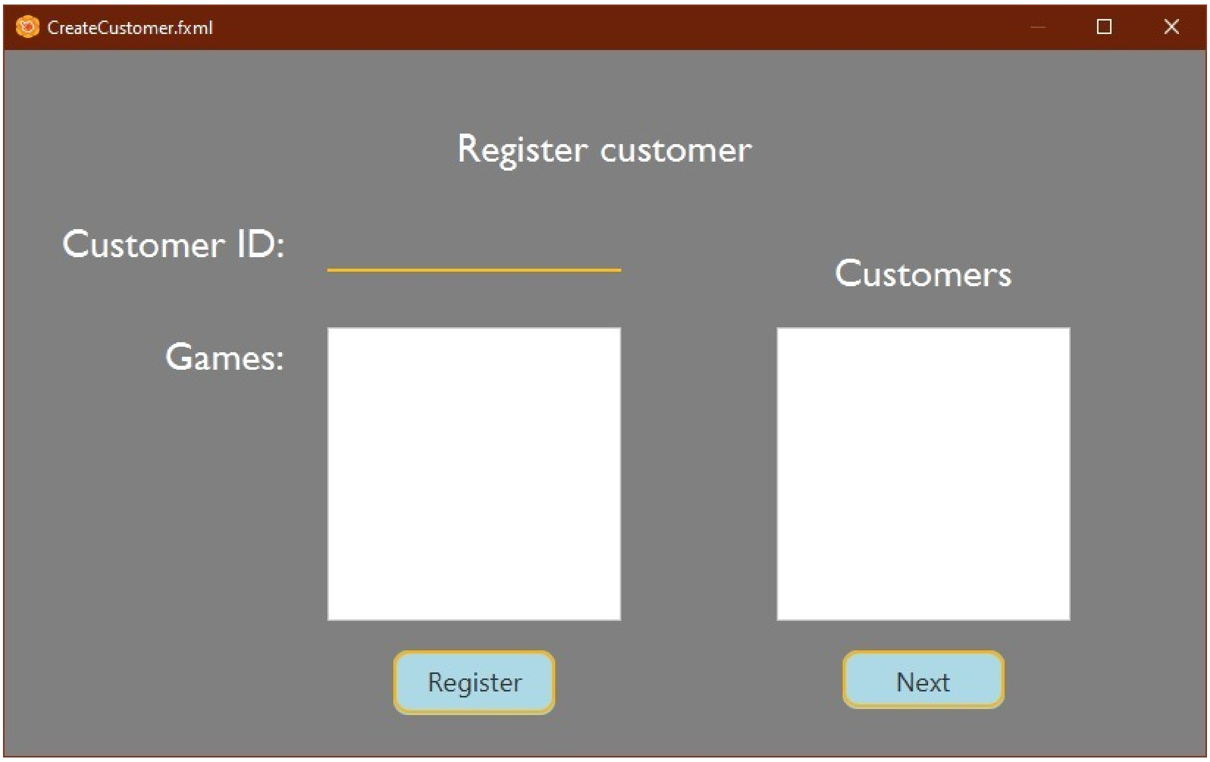
6.Design implementation:
Img #1(section 1): Screen of load(section 1) where the number of shelves, cash registers and customers.



Img #1: Screen where store settings are registered.



Img #2: Screen where games are registered.



Img #3: Screen where customers are registered.

Img #4: screen to sort games depending on the shelves and to show the time that each customer takes in order to show the most efficient route. And screen to show the final order of each customer which includes their games, total price and final time.

Functional Requirements

The program should be capable of:

- ➔ **Req1.** ***Register*** the basic data of the store, given in the input.
  - ◆ **Req1.1** ***Register*** the number of cashiers available during the day.
- ➔ **Req2.** ***Create*** the basic objects and data structures given the input
  - ◆ **Req2.1** ***Create*** the required shelves according to the corresponding line in the input.
  - ◆ **Req2.2** ***Create*** the store customers of the day according to the given input
  - ◆ **Req2.3** ***Create*** the required available cashiers of the day given the input
  - ◆ **Req2.4** ***Create*** the required games given the input
- ➔ **Req3.** ***Order*** each customer's set list according to shelf location in such a way that the buyer follows the best route.
- ➔ **Req4.** ***Implement*** the Stack structure to represent the automated basket that each customer has.

Complexity Analysis

INSERTION SORT

Temporal complexity

· Middle case

On average, i comparisons are made in the fifth pass of the insertion sort. Therefore, if there are n iterations, the mean time complexity can be as follows.

Therefore, the time complexity is of the order of [Big Theta]: O (n2).

· The worst case

The worst case occurs when the array is ordered inversely, and the maximum number of comparisons and exchanges must be performed.

The worst-case time complexity is [Big O]: O (n2).

· Best case

The best case occurs when the array is already ordered, and then the outer loop only executes n times.

The best-case time complexity is [Big Omega]: O (n).

Spatial complexity

The spatial complexity of the insertion sort algorithm is O (n) because no more memory is required than that of a temporary variable.

BUBBLE SORT

Time complexity

- Middle case

On average, n-i comparisons are made in the i-th pass of the bubble sort. Therefore, if there are n countries, the mean temporal complexity can be given by

Therefore, the temporal complexity is of the order of O (n2).

- The worst case

The worst case occurs when the array is ordered inversely, and the maximum number of comparisons and exchanges must be carried out.

The worst-case time complexity is O (n2).

- Best case

The best case is when the array is already ordered, and then only N comparisons are needed.

The best-case time complexity is O (n).

Spatial complexity

The spatial complexity of this algorithm is O (n) because no more memory is needed than a temporary variable.