

COMP47500 – Advanced Data Structures in Java

Assignment No: 4

Date: 15/04/2024

Title: Leveraging HashTable to handle bulk orders in an Order Management System

Code Link : https://github.com/COMP47500-Adv-Data-Structures-in-Java/Assignment_4

Execute: InventoryManager.java inside ie/ucd/csnl/comp47500

Assignment Type of Submission:			
Group	Yes/No	List all of group members' details:	% Contribution Assignment Workload
	Yes	Student Name : Prakash Jha Student ID : 2320077	25%
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1. Problem Domain Description:

The Order Management System (OMS) is a Java-based application designed to efficiently handle and process orders for a business. The system utilises HashTable data structure to store orders, providing fast retrieval and manipulation capabilities. It serves as a centralised platform for managing the lifecycle of orders, from creation to fulfilment.

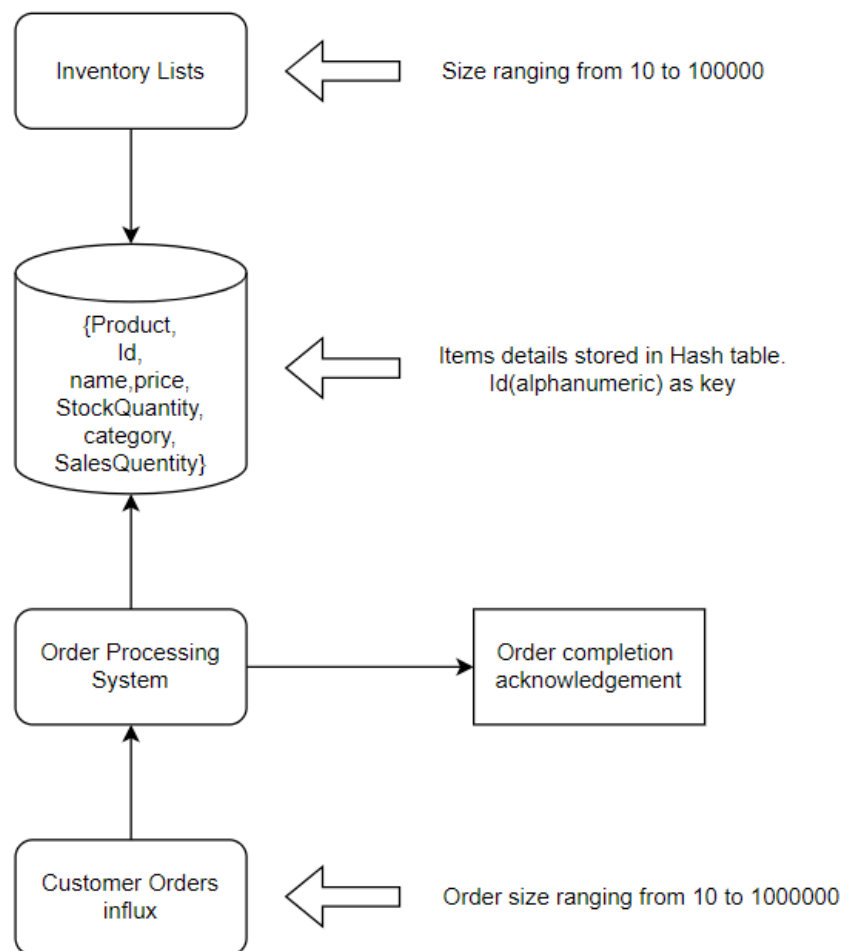
Key Features:

- **Order Processing:**

facilitates the processing of an order for a specified quantity of a product identified by its product ID. It first retrieves the product from the inventory based on the provided product ID. If the product exists, it checks if the current stock quantity is sufficient to fulfil the order. If there's enough stock, it records the sale by adjusting the stock quantity and returns a message confirming the successful order completion. If there's insufficient stock, it returns a message indicating the shortage. If the product is not found in the inventory, it returns a message stating so.

- **Order Price Adjustment:**

iterates through the inventory of products and adjusts their prices based on their stock quantities. If a product's stock quantity is less than 10 units, its price is increased by 10%. Conversely, if the stock quantity is over 50 units, the price is decreased by 10%. After adjusting the prices, it prints a message indicating that the prices have been adjusted based on stock levels.



The above diagram shows our use where we are storing the Product information in a hash table which acts as inventory of our products and the product ID acts as key for and (name, price, stock quantity, category, sales quantity) acts as value associated with unique key.

2. Theoretical Foundations of the Data Structure(s) utilised

Hash tables are using an associative array to store data in Key-value pairs. The key function of a hash table is to provide fast data retrieval. This accomplishes through the hash function which is converting the key into a hash code, which determines where the data is stored in the array.

1) Hash Function

Hash Function converts keys into index values that point where associated values are stored in the array. Hash function receives the key and calculates the hash code, which decides the location.

2) Handling Collisions

Minimising collision is the key to the efficiency of this data structure. Collision occurs when one index is assigned to multiple keys. The general methods to deal with the collision is chaining and open addressing, and we used chaining to deal with it. Chaining is to use more complex data structures such as a linked list to store multiple values in the same index while open addressing is to find an open slot.

3) Rehashing/Resizing

When more elements are added to a hash table, the number of entries divided by the number of buckets increases and this leads to more collisions. To improve the efficiency, resizing and rehashing all entries can be used. This will double the size of the array and recalculate the position of all entries.

Operations implemented in the project:

- `put(K key, V value)`: Puts the specified key-value pair into the map. If the key already exists, update its value. Resize the map if necessary.
- `get(int index, K key)`: Retrieves the value associated with the specified key from the map.
- `remove(int index, K key)`: Removes the entry associated with the specified key from the map.
- `containsKey(K key)`: Checks if the map contains the specified key.
- `size()`: Returns the number of key-value pairs in the map.
- `isEmpty()`: Checks if the map is empty.
- `clear()`: Clears the map by removing all key-value pairs.
- `generateHash(k)`: Computes a hash index for a key `k` using a hash function. This method determines the bucket location in the hash table.
- `hash(k)`: Calculates the initial hash code for a key `k`. It's used as a part of the hashing process before applying any compression methods.
- `generateHash(k)`: Computes a hash index for a key `k` using a hash function. This method determines the bucket location in the hash table.
- `hash(k)`: Calculates the initial hash code for a key `k`. It's used as a part of the hashing process before applying any compression methods.
- `getAllKeys()`: Returns a list of all keys present in the hash map, compiled by traversing through all buckets and their chains.
- `resize()`: Resizes the map by doubling its capacity and rehashing all existing entries.

Time complexity table for AbstractMap class's operations:

<code>generateHash(k)</code>	$O(1)$
<code>hash(k)</code>	$O(1)$
<code>get(k)</code>	$O(1)$

put(k,v)	O(1)
remove(k)	O(1)

Time complexity table for HashMapImpl class's operations(implement AbstractMap):

size()	O(1)
isEmpty()	O(1)
clear()	O(n)
buketPut(int, k,v)	O(1)
buketGet(int, k)	O(1)
buketRemove(int, k)	O(1)
containKey(k)	O(1)
resize()	O(n)
getAllKeys()	O(n)

3. Analysis/Design (UML Diagram(s))

DESIGN CONSIDERATIONS FOR MAP

We have considered the following parameters for designing the hashtable

1. Scale factor,A =314159265358979323
2. Shift, B = 271828182845904523
3. Load factor = 0.5

Shift and scale parameters have been chosen as they are able to prevent collisions for large numbers of inventories. The keys are more evenly distributed using fairly large prime numbers. The use of load factor at 0.5 means the table resizes itself when it reaches half of its capacity. It gives a fair balance between quick access for insertion and retrieval and the memory for the table.

Sequence Diagram

1. HASHTABLE PUT OPERATION (SEQ DIAGRAM 1)

The high level flow of the seq diagram is as below:

- User sends a list of inventories(products) to the system, which can be thought of as a warehouse or a retail storehouse.
- The InventoryManager upon receiving the bulk requests instantiates an Inventory class which holds the map of products represented by
- 88
 - Key - product ID
 - Value - Product bean
- Inventory invokes put method of HashMapImpl on receiving an addProduct request
- HashMapImpl class internally uses generateHash method to derive the index for the product in the hashtable.
- The product is added to the map directly if the index is empty or added to the chain

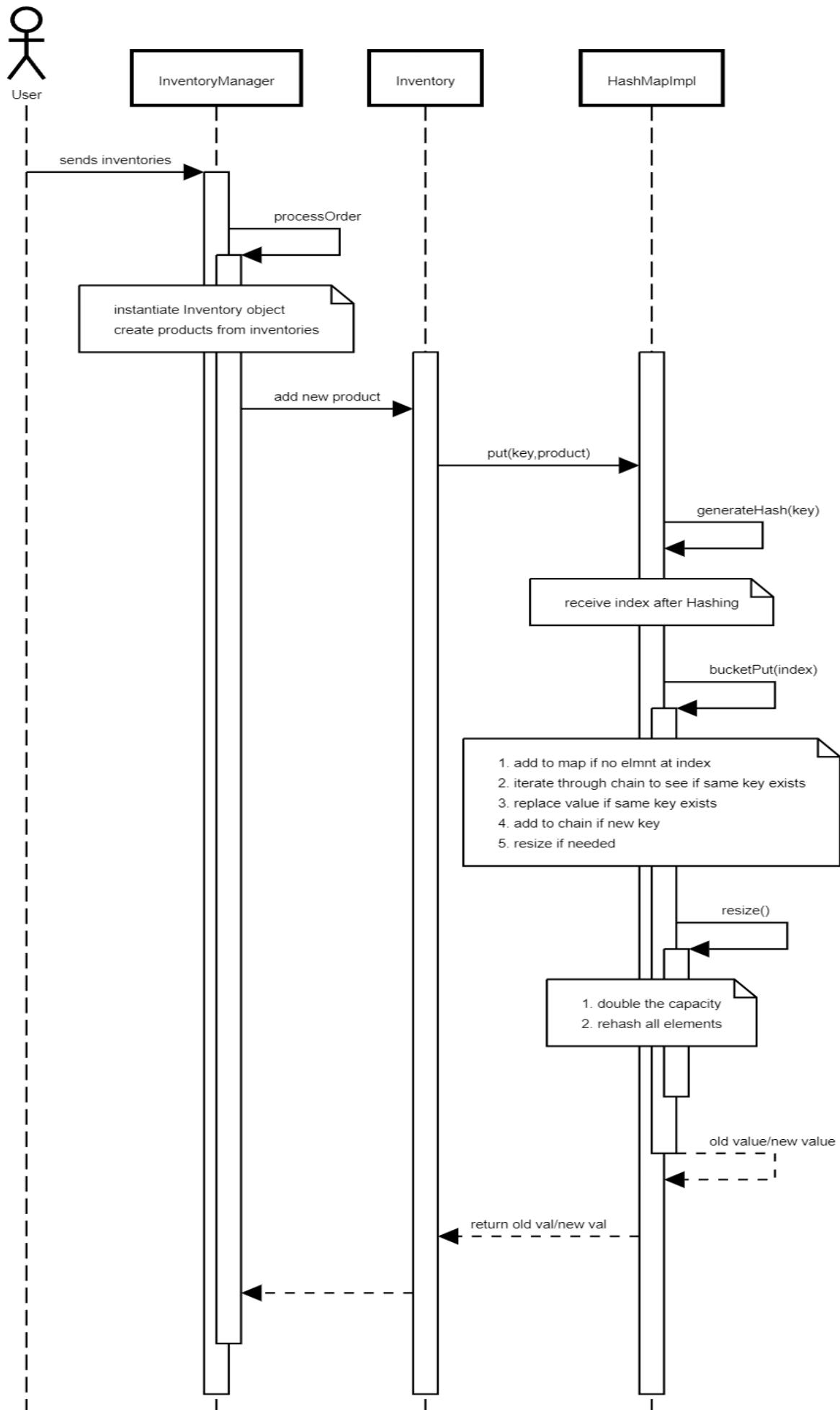
2. HASHTABLE GET/REMOVE OPERATION (SEQ DIAGRAM 2)

The high level flow of the seq diagram is as below:

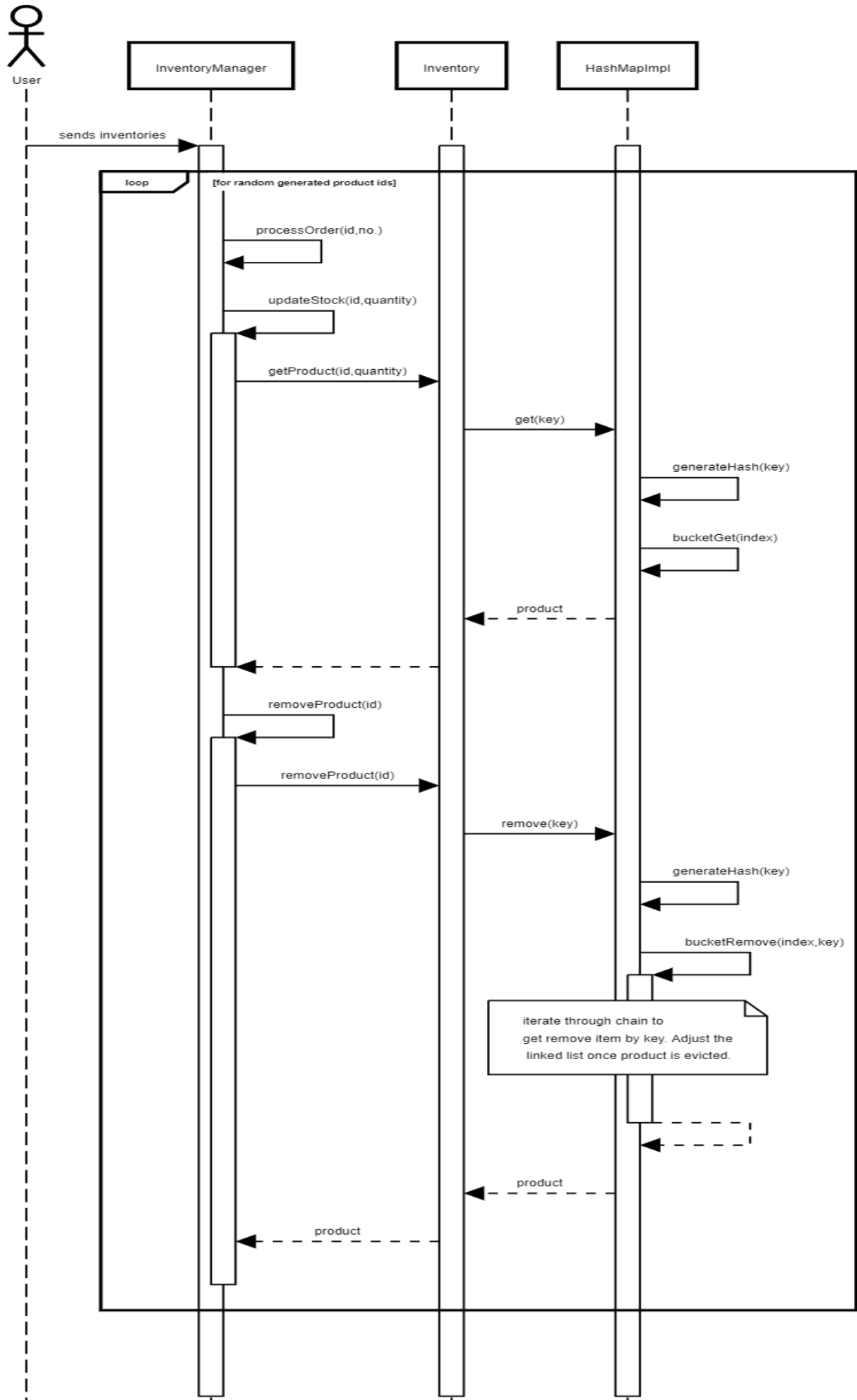
- For each product required to be processed,The InventoryManager does the following
 - updateStock
 - removeProduct
- When updateStock is invoked the InventoryManager redirects to the Inventory with the product ID. The product is retrieved from the hashtable using the get method.
- The quantity of the product in the stock is adjusted within the inventory class.
- When a product is to be removed from inventory, potentially when it is out of stock, the InventoryManager invokes the remove API of the Inventory class. The Inventory uses the remove method of the HashMapImpl to take it out of the inventory.

In the above cases the HashMapImpl makes use of protected methods like bucketPut, bucketGet and bucketRemove to implement corresponding logic.

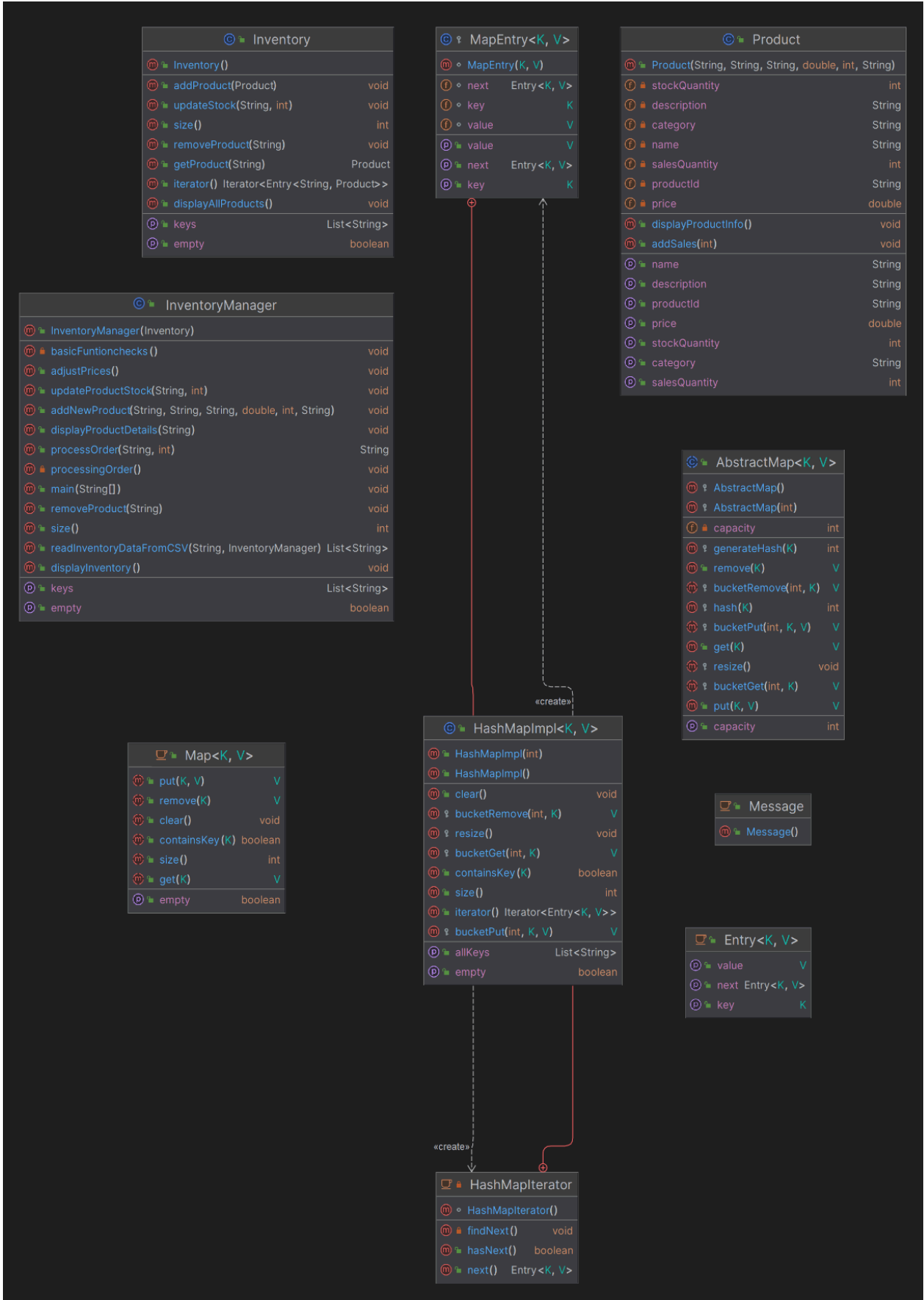
HashTable Put operation



Processing Orders using HashTables



Class Diagram:



4. Code Implementation:

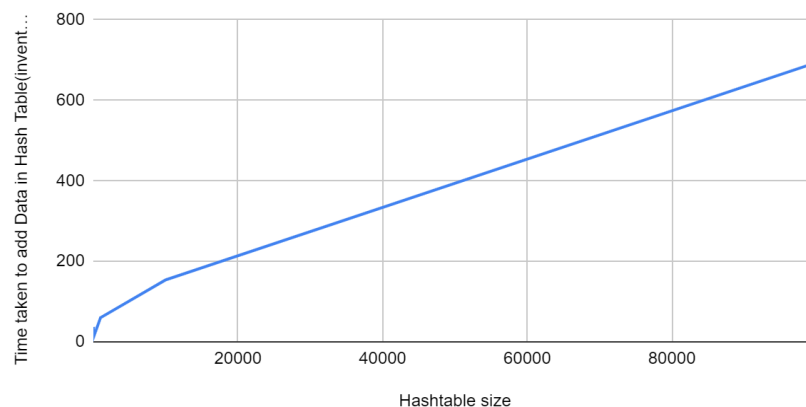
GitHub (link): https://github.com/COMP47500-Adv-Data-Structures-in-Java/Assignment_4

5. Set of Experiments run and results

Hash table size	Time taken to fill the hash table	Time taken for get and put operation for a single item	Time taken for delete operation for a single item	Time taken to check the size	The taken to check if hash is empty
10	37	25	0	1	0
100	15	1	0	0	0
1000	60	2	0	0	0
10000	154	0	0	0	0
100000	694	0	0	0	0

Graph 1:

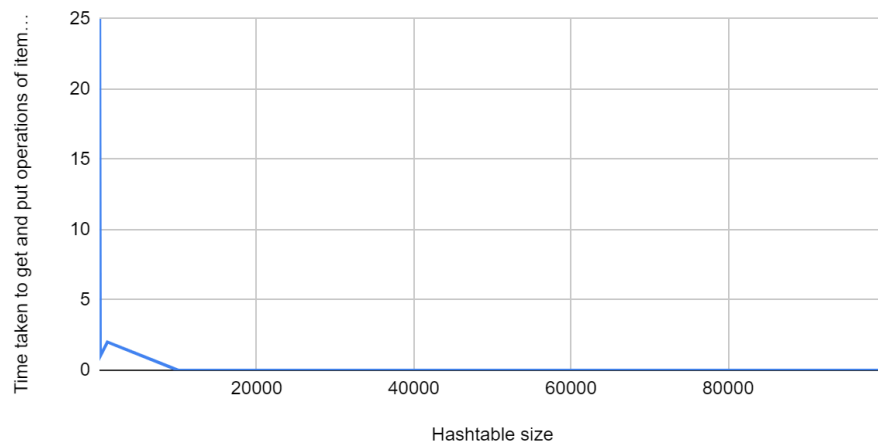
Time taken to add Data in Hash Table(inventory) vs Hashtable size



The above graph indicates the time taken to add data in HashTable. This is **$O(n)$** since we are adding data linearly reading from a data set and as the size increases the new blocks are introduced which increases the time and that in turn leads to **$O(n)$** .

Graph 2:

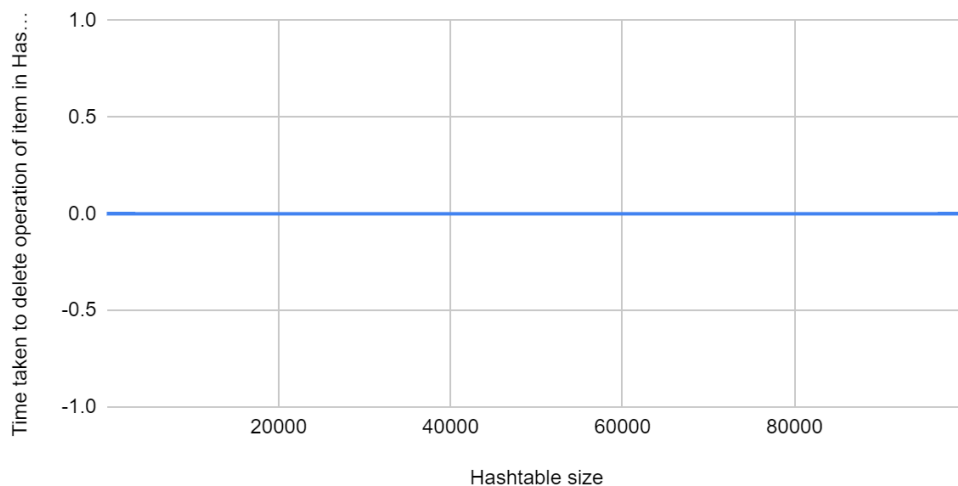
Time taken to get and put operations of item in Hash Table(inventory) vs Hashtable size



The above graph indicates the time taken to get or put a single item in hashmap, in this case since there is only a single item and as per the operations of hashmap it directly fetches the key(product Id) associated with that item the retrieval and updation of same block is **$O(1)$** .

Graph 3:

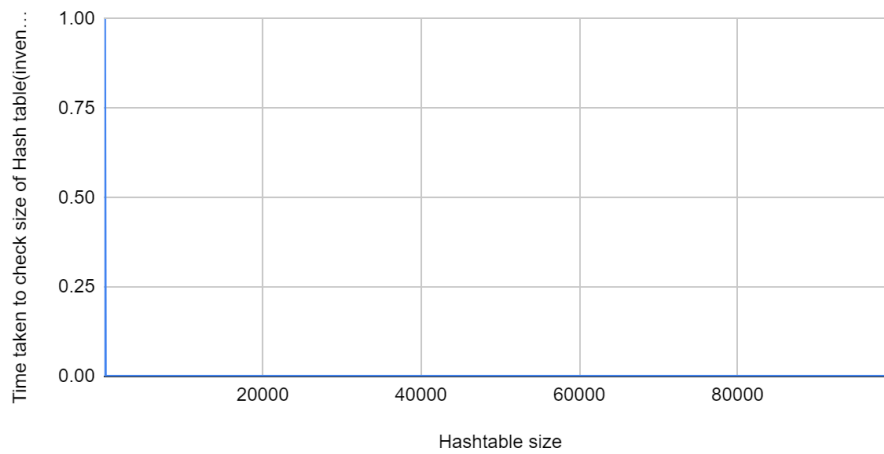
Time taken to delete operation of item in Hash Table(inventory) vs Hashtable size



The above graph indicates the time taken to delete a single item in hashmap, in this case since there is only a single item and as per the operations of hashmap it directly fetches the key(product Id) associated with that item and removes the block from hashmap leading to **$O(1)$** time complexity

Graph 4:

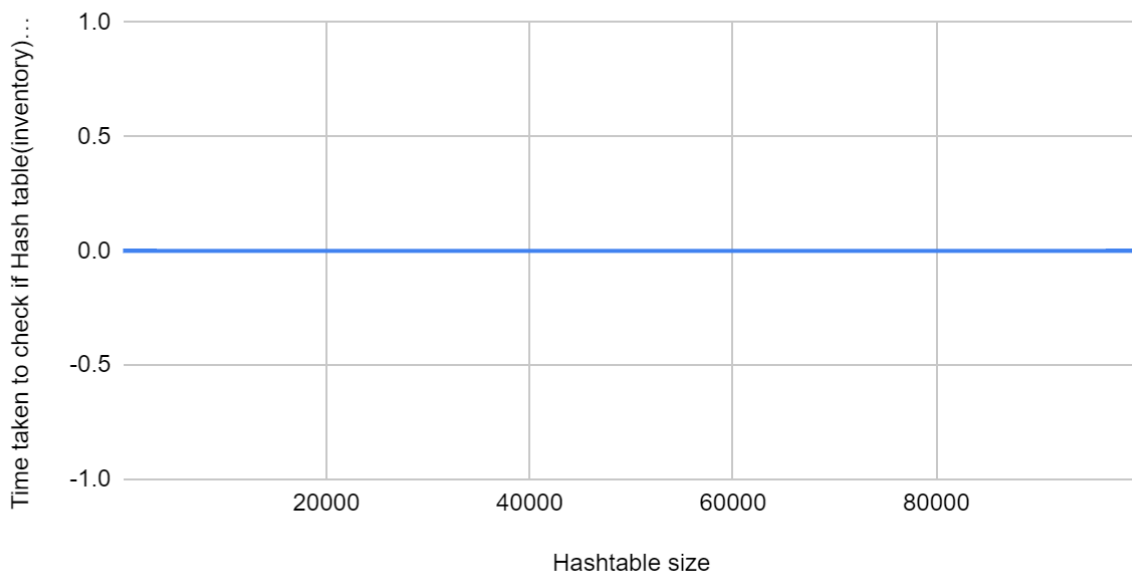
Time taken to check size of Hash table(inventory) vs Hashtable size



The above graph gives the analysis of size vs time taken to return the size of hashmap which is almost 0 irrespective of the size hence $O(1)$.

Graph 5:

Time taken to check if Hash table(inventory) is empty vs Hashtable size



The above graph gives the analysis of size vs time taken to return the if the Hash map is empty or not. This operation is independent of what size is in the hashmap, leading it to $O(1)$.

Execution output:

```
*****implementation of basic hashmap functions*****
Inventory Size10
initial Inventory:
Product ID: 2605d30f-32a0-4d1a-9327-598ee1577d85, Name: Fantastic Concrete
Gloves, Description: Ergonomic executive chair upholstered in bonded black
leather and PVC padded seat and back for all-day comfort and support,
Price: $686.0, Stock Quantity: 24, Category: Computers, Sales Quantity: 0
-----
Product ID: 62954a51-7c21-4c59-a785-06a8f2796384, Name: Bespoke Fresh
Salad, Description: The Nagasaki Lander is the trademarked name of several
series of Nagasaki sport bikes, that started with the 1984 ABC800J, Price:
$330.0, Stock Quantity: 11, Category: Outdoors, Sales Quantity: 0
-----
Product ID: 93d032e7-349b-49c1-83ce-9e92a38511b5, Name: Handmade Fresh Hat,
Description: New range of formal shirts are designed keeping you in mind.
With fits and styling that will make you stand apart, Price: $633.0, Stock
Quantity: 42, Category: Industrial, Sales Quantity: 0
-----
Product ID: c7e2139b-b2df-4496-818f-0271a64e0966, Name: Electronic Wooden
Bike, Description: Ergonomic executive chair upholstered in bonded black
leather and PVC padded seat and back for all-day comfort and support,
Price: $740.0, Stock Quantity: 8, Category: Grocery, Sales Quantity: 0
-----
Product ID: eda869d8-33d5-4184-a4e9-38ce2012b93d, Name: Unbranded Wooden
Towels, Description: New range of formal shirts are designed keeping you in
mind. With fits and styling that will make you stand apart, Price: $360.0,
Stock Quantity: 94, Category: Grocery, Sales Quantity: 0
-----
Product ID: eb82b173-ffc1-4731-a999-092fa375375e, Name: Sleek Wooden Mouse,
Description: Carbonite web goalkeeper gloves are ergonomically designed to
give easy fit, Price: $842.0, Stock Quantity: 79, Category: Garden, Sales
Quantity: 0
-----
Product ID: 79cee30d-970a-4be7-9e23-0dc523789e24, Name: Awesome Concrete
Pants, Description: Carbonite web goalkeeper gloves are ergonomically
designed to give easy fit, Price: $442.0, Stock Quantity: 19, Category:
Automotive, Sales Quantity: 0
-----
Product ID: bae29ef8-3540-41b8-a464-11d213bc046c, Name: Tasty Fresh Pizza,
Description: Andy shoes are designed to keeping in mind durability as well
as trends, the most stylish range of shoes & sandals, Price: $491.0, Stock
Quantity: 74, Category: Beauty, Sales Quantity: 0
-----
Product ID: 9b2795c9-a010-4cba-a5a5-bf0cca520db5, Name: Unbranded Metal
Car, Description: The Apollotech B340 is an affordable wireless mouse with
reliable connectivity, 12 months battery life and modern design, Price:
$448.0, Stock Quantity: 54, Category: Electronics, Sales Quantity: 0
-----
Product ID: fb7de8d1-9ba8-426d-9736-abe61b886ddb, Name: Awesome Fresh
Pants, Description: Ergonomic executive chair upholstered in bonded black
leather and PVC padded seat and back for all-day comfort and support,
Price: $541.0, Stock Quantity: 68, Category: Music, Sales Quantity: 0
-----
Updating stock for Smartphone
Product ID: P002, Name: Smartphone, Description: Latest model smartphone,
Price: $800.0, Stock Quantity: 5, Category: Electronics, Sales Quantity: 0
All keys in the inventory:
2605d30f-32a0-4d1a-9327-598ee1577d85
```

62954a51-7c21-4c59-a785-06a8f2796384
93d032e7-349b-49c1-83ce-9e92a38511b5
c7e2139b-b2df-4496-818f-0271a64e0966
eda869d8-33d5-4184-a4e9-38ce2012b93d
eb82b173-ffc1-4731-a999-092fa375375e
79cee30d-970a-4be7-9e23-0dc523789e24
bae29ef8-3540-41b8-a464-11d213bc046c
9b2795c9-a010-4cba-a5a5-bf0cca520db5
P002

fb7de8d1-9ba8-426d-9736-abe61b886ddb

final Inventory:

Product ID: 2605d30f-32a0-4d1a-9327-598ee1577d85, Name: Fantastic Concrete
Gloves, Description: Ergonomic executive chair upholstered in bonded black
leather and PVC padded seat and back for all-day comfort and support,
Price: \$686.0, Stock Quantity: 24, Category: Computers, Sales Quantity: 0

Product ID: 62954a51-7c21-4c59-a785-06a8f2796384, Name: Bespoke Fresh
Salad, Description: The Nagasaki Lander is the trademarked name of several
series of Nagasaki sport bikes, that started with the 1984 ABC800J, Price:
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Product ID: 93d032e7-349b-49c1-83ce-9e92a38511b5, Name: Handmade Fresh Hat,
Description: New range of formal shirts are designed keeping you in mind.
With fits and styling that will make you stand apart, Price: \$633.0, Stock
Quantity: 42, Category: Industrial, Sales Quantity: 0

Product ID: c7e2139b-b2df-4496-818f-0271a64e0966, Name: Electronic Wooden
Bike, Description: Ergonomic executive chair upholstered in bonded black
leather and PVC padded seat and back for all-day comfort and support,
Price: \$740.0, Stock Quantity: 8, Category: Grocery, Sales Quantity: 0

Product ID: eda869d8-33d5-4184-a4e9-38ce2012b93d, Name: Unbranded Wooden
Towels, Description: New range of formal shirts are designed keeping you in
mind. With fits and styling that will make you stand apart, Price: \$360.0,
Stock Quantity: 94, Category: Grocery, Sales Quantity: 0

Product ID: eb82b173-ffc1-4731-a999-092fa375375e, Name: Sleek Wooden Mouse,
Description: Carbonite web goalkeeper gloves are ergonomically designed to
give easy fit, Price: \$842.0, Stock Quantity: 79, Category: Garden, Sales
Quantity: 0

Product ID: 79cee30d-970a-4be7-9e23-0dc523789e24, Name: Awesome Concrete
Pants, Description: Carbonite web goalkeeper gloves are ergonomically
designed to give easy fit, Price: \$442.0, Stock Quantity: 19, Category:
Automotive, Sales Quantity: 0

Product ID: bae29ef8-3540-41b8-a464-11d213bc046c, Name: Tasty Fresh Pizza,
Description: Andy shoes are designed to keeping in mind durability as well
as trends, the most stylish range of shoes & sandals, Price: \$491.0, Stock
Quantity: 74, Category: Beauty, Sales Quantity: 0

Product ID: 9b2795c9-a010-4cba-a5a5-bf0cca520db5, Name: Unbranded Metal
Car, Description: The Apollotech B340 is an affordable wireless mouse with
reliable connectivity, 12 months battery life and modern design, Price:
\$448.0, Stock Quantity: 54, Category: Electronics, Sales Quantity: 0

Product ID: P002, Name: Smartphone, Description: Latest model smartphone,
Price: \$800.0, Stock Quantity: 5, Category: Electronics, Sales Quantity: 0

Product ID: fb7de8d1-9ba8-426d-9736-abe61b886ddb, Name: Awesome Fresh

Pants, Description: Ergonomic executive chair upholstered in bonded black leather and PVC padded seat and back for all-day comfort and support, Price: \$541.0, Stock Quantity: 68, Category: Music, Sales Quantity: 0

*****Time Complexity checks*****

Inventory of size ----->10

^^^^^^^^^^^^^^^^^^^^Time taken to check size: 0

^^^^^^^^^^^^^^^^^^^^Time taken to add data: 4

is the inventory empty?false

^^^^^^^^^^^^^^^^^^^^Time taken to check isEmpty: 0 ms.

Displaying details of Concrete gloves:

Product ID: 2605d30f-32a0-4d1a-9327-598ee1577d85, Name: Fantastic Concrete Gloves, Description: Ergonomic executive chair upholstered in bonded black leather and PVC padded seat and back for all-day comfort and support, Price: \$686.0, Stock Quantity: 24, Category: Computers, Sales Quantity: 0

Updating stock for Concrete gloves:

Processing orders:

Order completed for: fb7de8d1-9ba8-426d-9736-abe61b886ddb, 2 units.

Order completed for: 93d032e7-349b-49c1-83ce-9e92a38511b5, 25 units.

Order completed for: eda869d8-33d5-4184-a4e9-38ce2012b93d, 15 units.

inventory size10

^^^^^^^^^^^^^^^^^^^^Time taken for get and put operations of items in inventory: 3

Adjusting prices based on stock levels:

Prices adjusted based on stock levels.

Removing awesome fresh plants from inventory:

Final Inventory:

inventory size9

^^^^^^^^^^^^^^^^^^^^Time taken for remove operation of item in

inventory: 0

Inventory of size ----->100

^^^^^^^^^^^^^^^^^^^^Time taken to check size: 0

^^^^^^^^^^^^^^^^^^^^Time taken to add data: 8

is the inventory empty?false

^^^^^^^^^^^^^^^^^^^^Time taken to check isEmpty: 0 ms.

Displaying details of Concrete gloves:

Product ID: 2605d30f-32a0-4d1a-9327-598ee1577d85, Name: Fantastic Concrete Gloves, Description: Ergonomic executive chair upholstered in bonded black leather and PVC padded seat and back for all-day comfort and support, Price: \$686.0, Stock Quantity: 24, Category: Computers, Sales Quantity: 0

Updating stock for Concrete gloves:

Processing orders:

Order completed for: fb7de8d1-9ba8-426d-9736-abe61b886ddb, 2 units.

Order completed for: 93d032e7-349b-49c1-83ce-9e92a38511b5, 25 units.

Order completed for: eda869d8-33d5-4184-a4e9-38ce2012b93d, 15 units.

inventory size100

^^^^^^^^^^^^^^^^^^^^Time taken for get and put operations of items in inventory: 1

Adjusting prices based on stock levels:

Prices adjusted based on stock levels.

Removing awesome fresh plants from inventory:

Final Inventory:

inventory size99

^^^^^^^^^^^^^^^^^^^^Time taken for remove operation of item in

inventory: 0

Inventory of size ----->1000

```
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to check size: 0
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to add data: 28
is the inventory empty?false
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to check isEmpty: 0 ms.
Displaying details of Concrete gloves:
Product ID: 2605d30f-32a0-4d1a-9327-598ee1577d85, Name: Fantastic Concrete
Gloves, Description: Ergonomic executive chair upholstered in bonded black
leather and PVC padded seat and back for all-day comfort and support,
Price: $686.0, Stock Quantity: 24, Category: Computers, Sales Quantity: 0
Updating stock for Concrete gloves:
Processing orders:
Order completed for: fb7de8d1-9ba8-426d-9736-abe61b886ddb, 2 units.
Order completed for: 93d032e7-349b-49c1-83ce-9e92a38511b5, 25 units.
Order completed for: eda869d8-33d5-4184-a4e9-38ce2012b93d, 15 units.
inventory size1000
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken for get and put operations of items in
inventory: 1
Adjusting prices based on stock levels:
Prices adjusted based on stock levels.
Removing awesome fresh plants from inventory:
Final Inventory:
inventory size999
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken for remove operation of item in
inventory: 1
```

```
Inventory of size ----->10000
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to check size: 1
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to add data: 150
is the inventory empty?false
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to check isEmpty: 0 ms.
Displaying details of Concrete gloves:
Product ID: 2605d30f-32a0-4d1a-9327-598ee1577d85, Name: Fantastic Concrete
Gloves, Description: Ergonomic executive chair upholstered in bonded black
leather and PVC padded seat and back for all-day comfort and support,
Price: $686.0, Stock Quantity: 24, Category: Computers, Sales Quantity: 0
Updating stock for Concrete gloves:
Processing orders:
Order completed for: fb7de8d1-9ba8-426d-9736-abe61b886ddb, 2 units.
Order completed for: 93d032e7-349b-49c1-83ce-9e92a38511b5, 25 units.
Order completed for: eda869d8-33d5-4184-a4e9-38ce2012b93d, 15 units.
inventory size10000
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken for get and put operations of items in
inventory: 0
Adjusting prices based on stock levels:
Prices adjusted based on stock levels.
Removing awesome fresh plants from inventory:
Final Inventory:
inventory size9999
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken for remove operation of item in
inventory: 0
```

```
Inventory of size ----->100000
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to check size: 1
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to add data: 460
is the inventory empty?false
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^Time taken to check isEmpty: 0 ms.
Displaying details of Concrete gloves:
Product ID: 2605d30f-32a0-4d1a-9327-598ee1577d85, Name: Fantastic Concrete
```



```

Gloves, Description: Ergonomic executive chair upholstered in bonded black
leather and PVC padded seat and back for all-day comfort and support,
Price: $686.0, Stock Quantity: 24, Category: Computers, Sales Quantity: 0
Updating stock for Concrete gloves:
Processing orders:
Order completed for: fb7de8d1-9ba8-426d-9736-abe61b886ddb, 2 units.
Order completed for: 93d032e7-349b-49c1-83ce-9e92a38511b5, 25 units.
Order completed for: eda869d8-33d5-4184-a4e9-38ce2012b93d, 15 units.
inventory size100000
^^^^^^^^^^^^^^^^^^^^Time taken for get and put operations of items in
inventory: 0
Adjusting prices based on stock levels:
Prices adjusted based on stock levels.
Removing awesome fresh plants from inventory:
Final Inventory:
inventory size99999
^^^^^^^^^^^^^^^^^^^^Time taken for remove operation of item in
inventory: 0

-----

Keeping Inventory size as 10000 and changing order size
Processing 10 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to process 10 orders: 0 ms.
Updating 10 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to update 10 orders: 0 ms.
is the inventory empty?false
^^^^^^^^^^^^^^^^^^^^Time taken to check isEmpty: 0 ms.
Removing 10 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to remove 10 orders: 0 ms.

-----

Processing 100 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to process 100 orders: 0 ms.
Updating 100 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to update 100 orders: 0 ms.
is the inventory empty?false
^^^^^^^^^^^^^^^^^^^^Time taken to check isEmpty: 1 ms.
Removing 100 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to remove 100 orders: 0 ms.

-----

Processing 1000 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to process 1000 orders: 2 ms.
Updating 1000 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to update 1000 orders: 1 ms.
is the inventory empty?false
^^^^^^^^^^^^^^^^^^^^Time taken to check isEmpty: 0 ms.
Removing 1000 orders from 10000 inventory
^^^^^^^^^^^^^^^^^^^^Time taken to remove 1000 orders: 1 ms.

```

6. Video of the Implementation running

Recording link: https://drive.google.com/file/d/1IJQcRdlbK-VxJDcBVkLNUehU7_-37-0j/view?usp=sharing

Comments: uploaded video recording in google drive.

7. References

HashTable (Java SE 10 & JDK 10). (n.d.).

<https://docs.oracle.com/javase/10/docs/api/java/util/Hashtable.html>

The MIT Press, Massachusetts Institute of Technology. (2024, January 12). *Book details - MIT Press*. MIT Press.

<https://mitpress.mit.edu/9780262533058/introduction-to-algorithms/>