Object Oriented Design and Programming

CSCI 50700 Assignment-5

Love Modi
Department of Computer Information and Science
Indiana University Purdue University Indianapolis, USA

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1 Introduction

The client desires an online marketplace where they can sell goods (and possibly services) to customers geographically dispersed around the world. Think Amazon but on a smaller scale and budget. Their desire is to have a system that is constructed in a portable language (Java) and makes use of their existing network. The system itself should present a view for the customer to interact with as well as a view for the employees or administrators of the company to interface with. For the customer there is a need for them to be able to browse available products – this should present the customer with the type, description and price of the item with the options to add to their shopping cart. If the customer attempts to add a quantity of the item more than the current supply the system should prevent the customer from adding these and prompt them with a message on the availability of the item. The customer should be able to also purchase their items from the shopping cart. This shopping cart should maintain state and be persistent through interactions with the application. The administrators should be able to update an item's description within the system, update its price, and update its quantity. The administrator should also be able to remove items from the system if so desired. Administrators should be able to add other administrators as well as add/remove customer accounts. On the other hand, a customer should be able to initially register for their account by themselves. The system should handle any faults or unexpected scenarios gracefully.

1.1 Requirements

Below are the requirements, segregated from client's application description

- Separate views for customer and administrator, so separate interface for customer and admin
- Customer should be able to browse available products
    - type, description and price of the item
    - the options to add to their shopping cart
- If the customer attempts to add a quantity of the item more than the current supply the system should prevent the customer from adding these and prompt them with a message on the availability of the item.
- The customer should be able to also purchase their items from the shopping cart
- Shopping cart should have persistent storage
- The administrators should be able to update an item's description within the system, update its price, and update its quantity
- The administrator should also be able to remove items from the system if so desired.
- Administrators should be able to add other administrators as well as add/remove customer accounts
- administrators cannot register for accounts.
- customer should be able to initially register for their account by themselves.
- Administrator cannot purchase items in that role
- The system should handle any faults or unexpected scenarios gracefully

2 Domain Model

Based upon feedback from the previous assignment, updated domain model is as below:

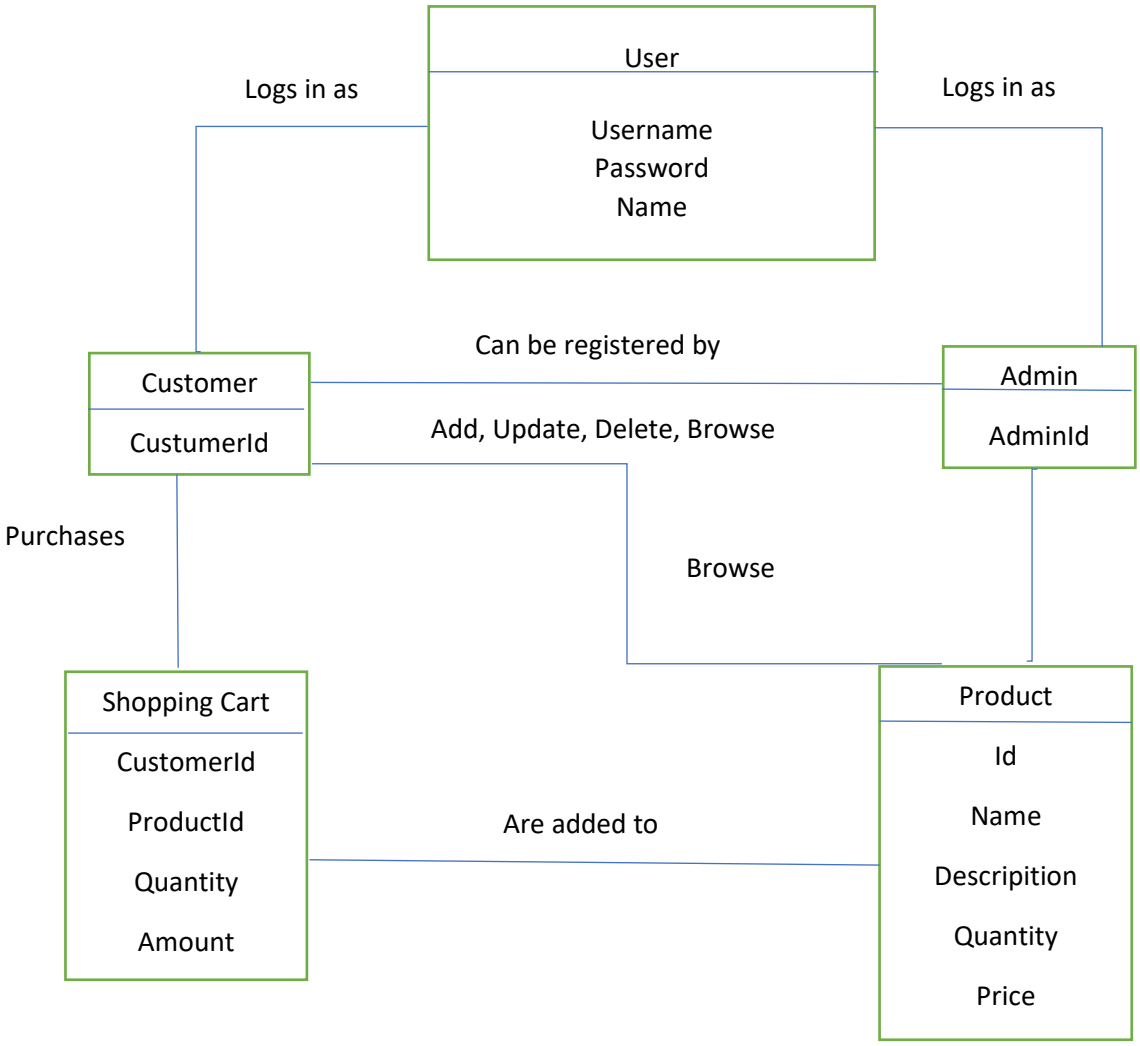


Fig 1. Domain Model

Our domain will consist of the above-mentioned entities which will interact with each other to successfully fulfil the business requirements.

3 Software Design

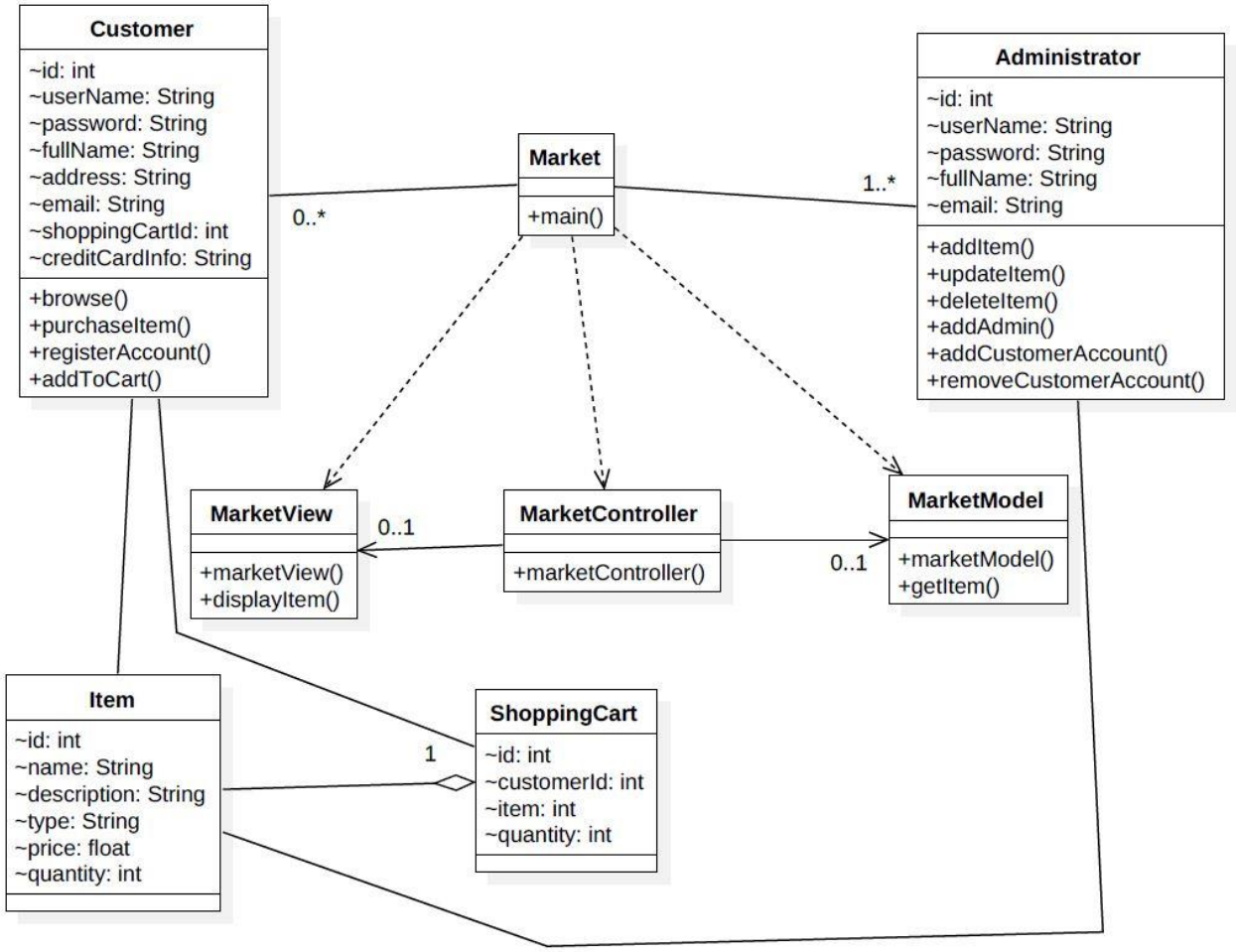


Fig 2. Software Design

The above figure shows that this application will have two types of users:

- Customer
- Administrator

Below are the entities within the domain model derived from the description:

- MarketView (View served on application startup to client)
- MarketModel (Serves as model for our MVC pattern)
- Item
- ShoppingCart
- Market

- MarketClient and MarketServer (serves as MarketController)
- Customer
- Administrator

Below are the actions that a customer would be able to perform:

- browse items
- purchase Items
- register his account
- add items to his cart

Below are the actions that an Administrator would be able to perform:

- Add an administrator
- Add/remove customer account
- Add item
- Update item description
- Delete item

4 Implementation of Java RMI and MVC

This application is designed and implemented using the Model-View-Controller (MVC) architectural pattern and connects to remote hosts using the Java Remote Method Invocation (RMI) framework.

Java RMI is used in a client/server fashion. The MVC architecture is incorporated in this design by considering the view (MarketView) on the client side, model (MarketModel) on the server side. The MarketClient and the MarketServer act as controllers on the client and server ends, used to relay communication between client and server. The design for controllers is chosen in this way so that the application control can be handled effectively at both client and server ends. The Market class is as an interface used for RMI implementation. This way the Model, View and the Controller remain loosely coupled so that changes in one class do not necessarily affect other.

To implement Java RMI below libraries are imported at client and server end:

- Client
  - import java.rmi.Naming;
- Server
  - import java.rmi.Naming;
  - import java.rmi.RemoteException;
  - import java.rmi.server.UnicastRemoteObject;

The class java.rmi.Naming is used to bind the reference of MarketServer instance with the servers location (name) at the RMI registry. This name is used by the client to lookup the Market interface in the RMI registry to invoke remote methods that the server will execute. This registration happens using the below method:

Naming.rebind(name, market);

Here name is the server's location and market is a reference to MarketServer class.

5 Updates to the project

Application of synchronization patterns and implementation of all the functionalities was the crux of this assignment. Please refer section 9 and onwards for all the information regarding the same. No new classes added as a part of assignment #5

6 AbstractFactory, FrontController and Command Pattern

For this assignment abstract factory, front controller and command patterns have been implemented to ensure loose coupling, separation of concerns and high cohesion with our system while implementing the login functionality.

For abstract factory pattern, the client interacts only with the FactoryCreator class to get an MarketFactory instance cast as an AbstractFactory. The AbstractFactory class (abstract class) is implemented by the MarketFactory which in turn provides the required view to the user again cast as an (abstract) MarketView. The client can consume this object and trigger the required methods on it and only deals with the abstract layer that we built over the concrete classes that supply the object instances.

FrontController is the central controller responsible for managing different client-side views. It lies between the client and the application controllers and delegates client commands between them. For this assignment, the FrontController is responsible for delegating client authentication request to the application controllers and receiving their response. If authentication is a successful, it asks the dispatcher to dispatch the relevant view according to the user category (admin or customer). The dispatcher validates the username and requests a view from the FactoryCreator. In case of unsuccessful authentication, the FrontController rejects the client request and appropriate message is shown on the client.

Command pattern is used to perform authentication at the backend (server-side). Once the request successfully reaches the MarketServerController, it creates a user object instance. The Authenticate command instance is also created. MarketModel acts as an invoker and executes the command as soon as the client requests an event. Command interface is implemented by Authenticate class. This ensures that the MarketModel (invoker) is able to execute the command (subscribed by all commands) without worrying about the command has been implemented.

Figure below captures the entire market app updated software design until now:

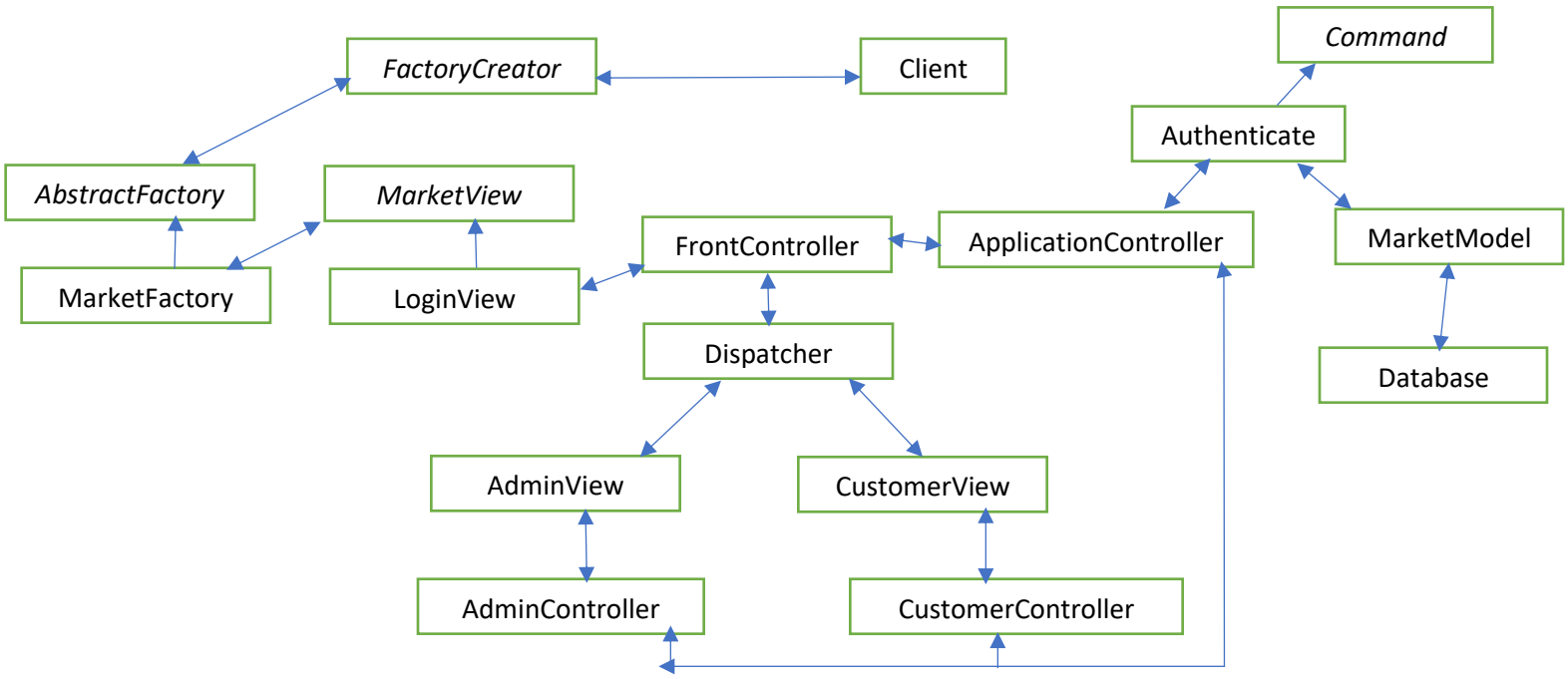


Fig 3. MarketApp Model with 3 design patterns

7 Authorization, Proxy and Reflection Pattern

Authorization pattern is used to provide the application the right kind of security and access that the system requires. Role based authorization is a type of authorization pattern which uses reflection pattern and proxy pattern for implementation. In Role-based authorization, the user access to a method is determined based on the user's role. Since we are using Java RMI the RMI interface will work as the proxy for Role-based authorization. A server implementation class was created which implements all the methods that are present in the market interface. An authorization invocation handler was also created which checks whether the user role allows access to a specific method.

An annotation class was also created which contains the annotation that has role type as an argument which will be used to match against the user role to provide access.

```
@Target({ElementType.TYPE, ElementType.METHOD})
@Retention(RetentionPolicy.RUNTIME)
public @interface RequiresRole {
        String value();
}
```

So, all the methods that need to have access control will have annotation like:

```
@RequiresRole("admin")
public void updateProduct(Session session, Item item);
```

Previously where the server was calling the RMI interface it will now call the authorization invocation handler which will check if the user should be provided access to the method or not.

Marketplace assignment = (Marketplace) Proxy.newProxyInstance(Marketplace.class.getClassLoader(), new Class<?>[] {Marketplace.class},new AuthorizationInvocationHandler(new ServerImpl()));

A simplified software design is shown below along with the sequence diagrams:

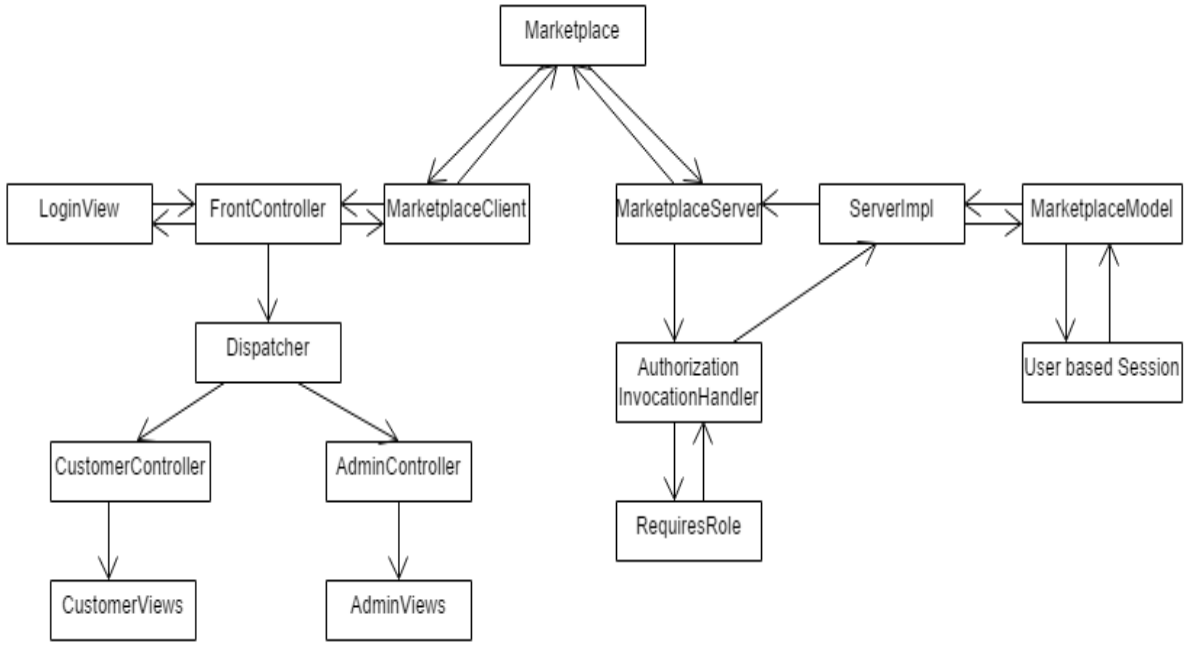


Fig 4. MarketApp Model with Authorization Pattern

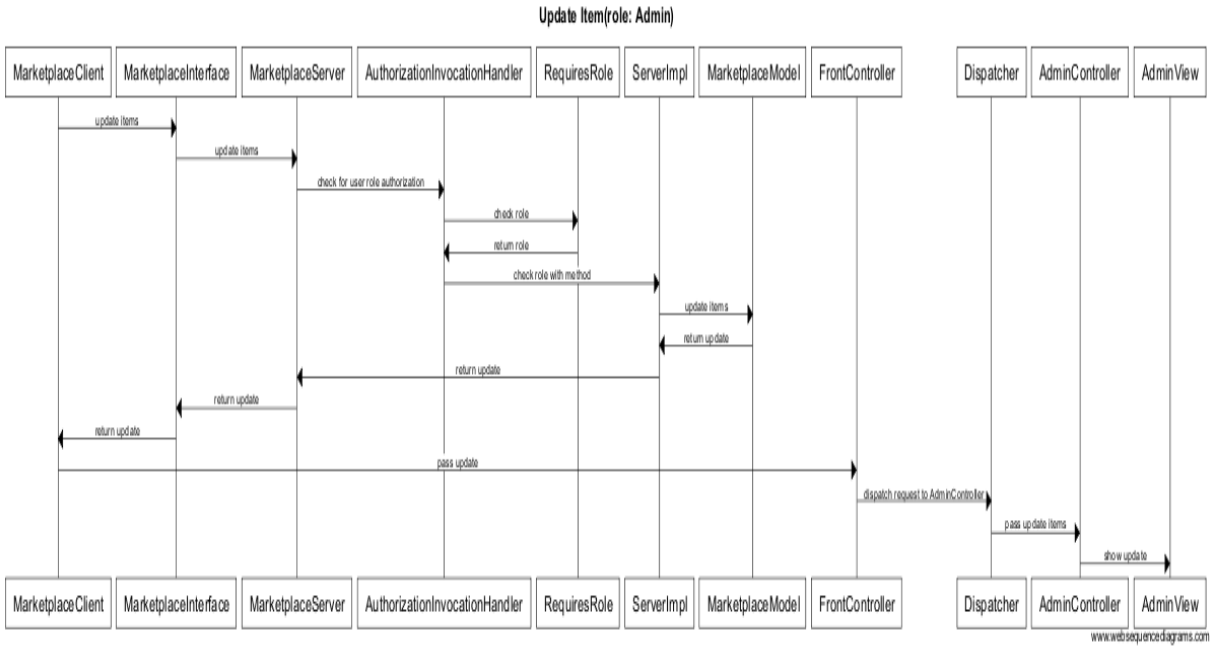


Fig 5. Sequence Diagram to Update Product

8 RMI Concurrency Discussion

To implement add items, purchase items and browse items functionality and test concurrency, I've used a persistent MySQL database here. Below is the sequence diagram to implement the above-mentioned methods.

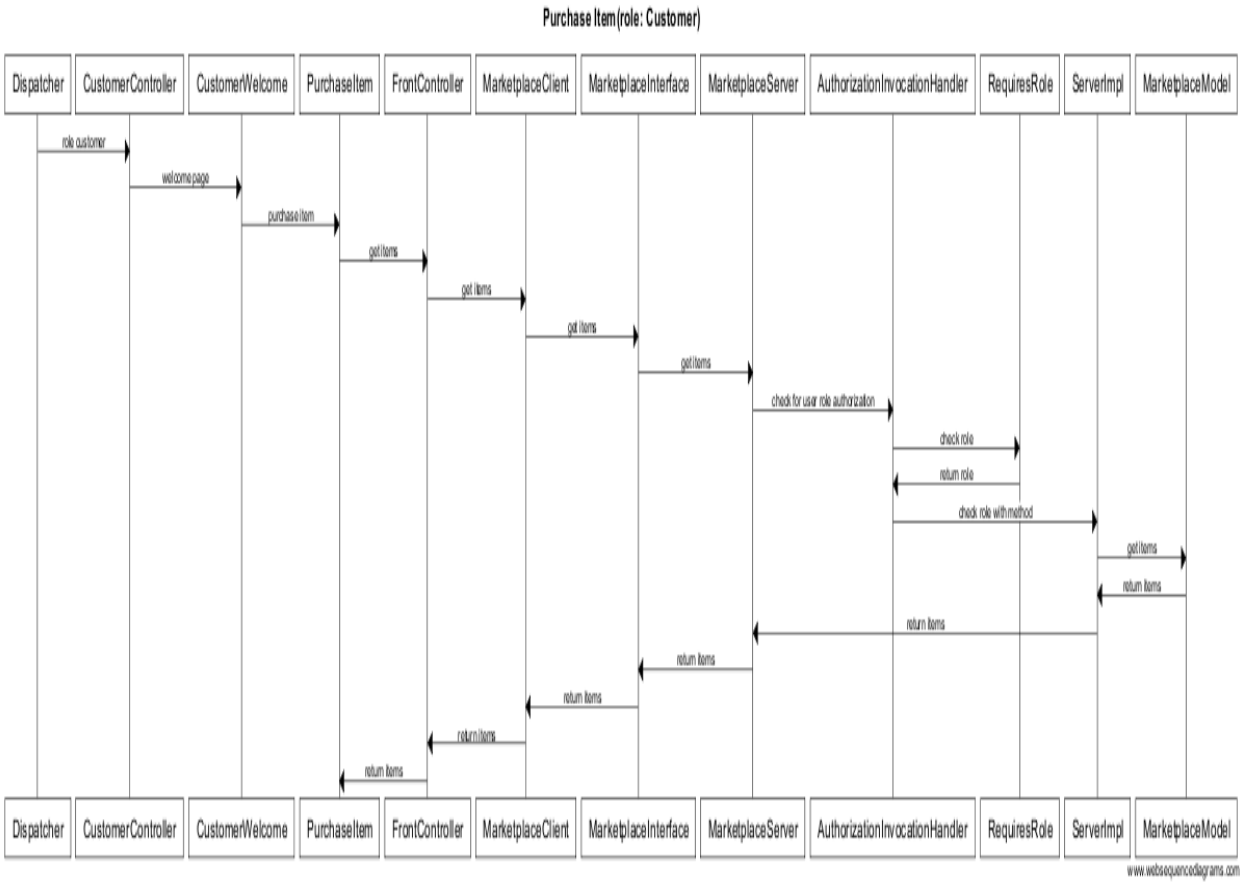


Fig. 7 Sequence Diagram for purchase item

To test concurrency, I've used Machine01 (10.234.136.55) as my server and the rest as my clients. Upon launching 5 clients and 1 server, RMI was able to handle the application and maintain distributed connections with all the clients. Hence it proved that RMI is a multi-threaded framework. Next, the application was tested for synchronization and concurrency.

I found that when only a single quantity of a product was left, and two users were trying to access it at the same time, the system allowed both the users to purchase the product, which is wrong. This proved that RMI does not guarantee concurrency. One solution can be to allow only one user to access the method while the other user needs to wait. This is possible using the keyword synchronized for critical methods like the purchase items, add items, browse items etc. which directly interact with the database. Snapshots for my experiments have been attached in the sample tests section.

One other problem that might occur is when two admins try to add the same product with the same price and description at the same time then two different entries will be created instead of one. Solution can be to allow only one admin to go ahead and then check the other entry if the product already exists then prompt for confirmation. Another solution can be to allow only one admin login at any time.

We need to use synchronization on the methods to let only one client access the read or write in the file. This way multiple client writing to the same file can be prevented and we may not have the above-mentioned issues.

9 Synchronization

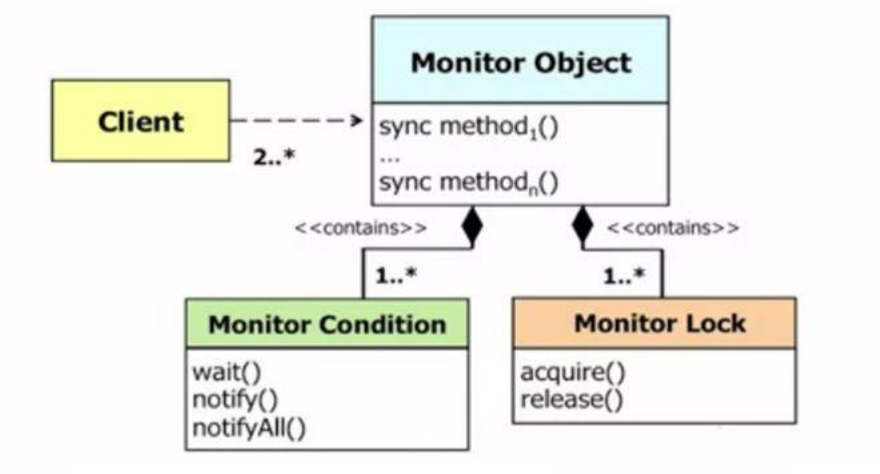
- ## Assignment #5 Implementation

  In assignment #5, synchronization patterns were such as Monitor Object, Future Pattern, Guarded Suspension, Thread-safe Interface and Scoped locking were required to be implemented. Below is a brief explanation how I have used the below pattern in my application:

  Monitor Object Pattern:

  Idea behind monitor object pattern is to monitor your object and make sure that it only allows to run one method at a time in that object. So, one needs to provide such a mechanism that only one thread can pass through that critical section and no other thread can get into that critical section until the current thread completes its execution.

  Following is the diagram of monitor object pattern:



  Now that a basic understanding of the monitor object pattern has been established, I want to describe how it has been used in this assignment. To achieve a situation where an object level lock is acquired when the thread is trying to access a critical section and the lock is released as soon as the work is done, I have used Java's built in synchronized keyword and applied it at method level. This is Java's built in implementation of the monitor object

pattern and can be used very easily by applying the synchronized key word at block or method level. I've used it on critical methods (add product, delete product, remove customer etc.) within the MarketModel class where I felt that there is need to ensure synchronization such that two customers or admins do not have to face ambiguous/ dirty data situations.
A comparison between method level usage and block level usage of the synchronized keywork.

Method level use of synchronization:

```
public synchronized void removeItem(List<String[]> items){
        //method implementation
}
```

As seen from the above example, the use of synchronized keyword at the method level puts the whole method in the critical section. This establishes a "happens-before" relationship with any subsequent invocations of the synchronized method in the same object.
It is not possible for two invocations of synchronized methods on the same object to interleave. When one thread is executing a synchronized method for an object, all other threads that invoke synchronized methods for the same object are blocked until the first thread is done with the object. This may sometimes create unnecessary overhead in the situations where there is no need for the other thread to wait for the completion of execution of the other thread. One solution to this is using the statement level synchronization.

Block level use of synchronization:

```
public void removeItem(List<String[]> items){
        List<String[]> catalog = new ArrayList <String[]>();
        catalog.addAll(items);
        synchronized(this){
                removeProducts(catalog);
        }
        catalog.clear();
}
```

Unlike method level synchronization we must specify the statements that provides the lock. This provides finer synchronization than the synchronized method. This helps synchronizing only the potion of the method that needs to be synchronized leaving the other portion out of the critical section.

If the entire method is part of the critical section, then there is no difference between using the method level or statement level synchronization. If the method has parts that don't need to be in the synchronized block, then statement level synchronization is more effective to use. The disadvantage to this is that the more the synchronized blocks, the less overall parallelism we get, so it is better to keep the synchronized statement level to the minimum.

- **Future Pattern**:
  Idea behind this pattern is to provide the client with a promise or a dummy object whenever the client is trying to access object or on-going computation result is not readily available. This dummy data object keeps the track of the state of running computation and once computation for the object is done, it provides the result to the client.
  In my application, I have not used future pattern since I do not have any heavy computation jobs or requests running where my application will get stuck for a long period of time. Implementation of the monitor object pattern has solved my problems wherein I'm able to get a smooth running fast application with 5 clients operating in tandem.

  Below is an example class where future pattern can be used:

```
private static final ExecutorService threadpool =Executors.newFixedThreadPool(1);

DatabaseConnection task = new DatabaseConnection ();

Future<Connection> future = threadpool.submit(task);

while (!future.isDone()) {
        System.out.println("Waiting for database connection....");
        Thread.sleep(5);
}

Connection conn = (Connection) future.get();

@Override
public Connection call()
{
        Connection conn = null;
        try {
                conn =  dbconnect();
        }
        catch (InterruptedException ex)
        {
                System.out.println(ex);
        }
        return conn;
 }

public Connection dbConnect() throws InterruptedException        {
                Connection conn = null;
                String hostname = "in-csci-rrpc01.cs.iupui.edu:3306";
                String dbName = "[tablename]_db";
                String url = "jdbc:mysql://" + hostname + "/" + dbName;
                String username = "[username]";
                String password = "[password]";
                System.out.println("Connecting database...");
```

```
try
{
        conn = (Connection) DriverManager.getConnection(url, username,
        password);
        System.out.println("Database connected!");
}
catch (SQLException e)
{
        throw new IllegalStateException("Cannot connect the
database!",e);
}
return conn;
}
```

Until the connection is made we have the future object that was returned immediately when we submitted the task, so we can continue the execution.
We keep check if the actual connection is ready using the while loop. When the connection is ready, we use the future.get() to get the result. Thread is put to sleep for some time instead of aborting the thread execution.

```
while (!future.isDone()) {
        System.out.println("Waiting for database connection....");
        Thread.sleep(5);
}
```

When the connection is ready we use the get method to get the connection.

```
Connection conn = (Connection) future.get();
```

We throw the Interrupted Exception if there is an exception in the thread execution. Thus, we do not have to wait until the connection is established to continue with the execution.

This pattern is useful only if there is something to execute between the time the call is made, and the value is returned. In my implementation of marketplace, I need the connection immediately to execute the query so using future pattern is not useful, so I have not used the future pattern.

- **Guarded Suspension**:
  For guarded suspension, the client gets access to a thread if some condition becomes true which enables the thread to get access to the object which contains the critical section. If condition is false, then client can't access to the code and client goes into wait status. Once the condition satisfies, all the clients are notified and the client first in the queue gets an access to that critical section within the object.
  This has been achieved by implementing synchronized keyword at places where I require that once the condition is satisfied then the thread should be unblocked otherwise it should stay in wait state. Once the condition is satisfied, notify all the waiting thread to get into ready state. All this has been done using synchronized keyword.

- **Scoped Locking**
  In Scoped locking, one needs to lock the scope of the code for a single thread and release the lock once the execution of that critical section is completed, hence providing thread safe environment and preventing dead lock scenarios.
  I have achieved this using synchronized keyword. Once the thread enters in a critical section, the Java prohibits other threads from accessing that object containing the critical section and once the execution is complete, Java releases the acquired lock lock hence other threads can get access to the object.

- **Thread-Safe Interface**
  The idea is to put the lock at the interface level rather than the implementation level. The objective of this pattern is to prevent self-deadlock. If the lock is kept at both implementation level and interface level, there is a chance that the lock at implementation level does not get released, which will prevent the interface level lock to release its own lock, hence creating deadlock.
  To implement Thread-Safe locking in my application, I used the synchronized keyword at the top of a method and not within the method at block level. This has ensured that synchronized keyword doesn't appear at both block and method level creating deadlock condition.
  Below example describes an application of thread safe interface:

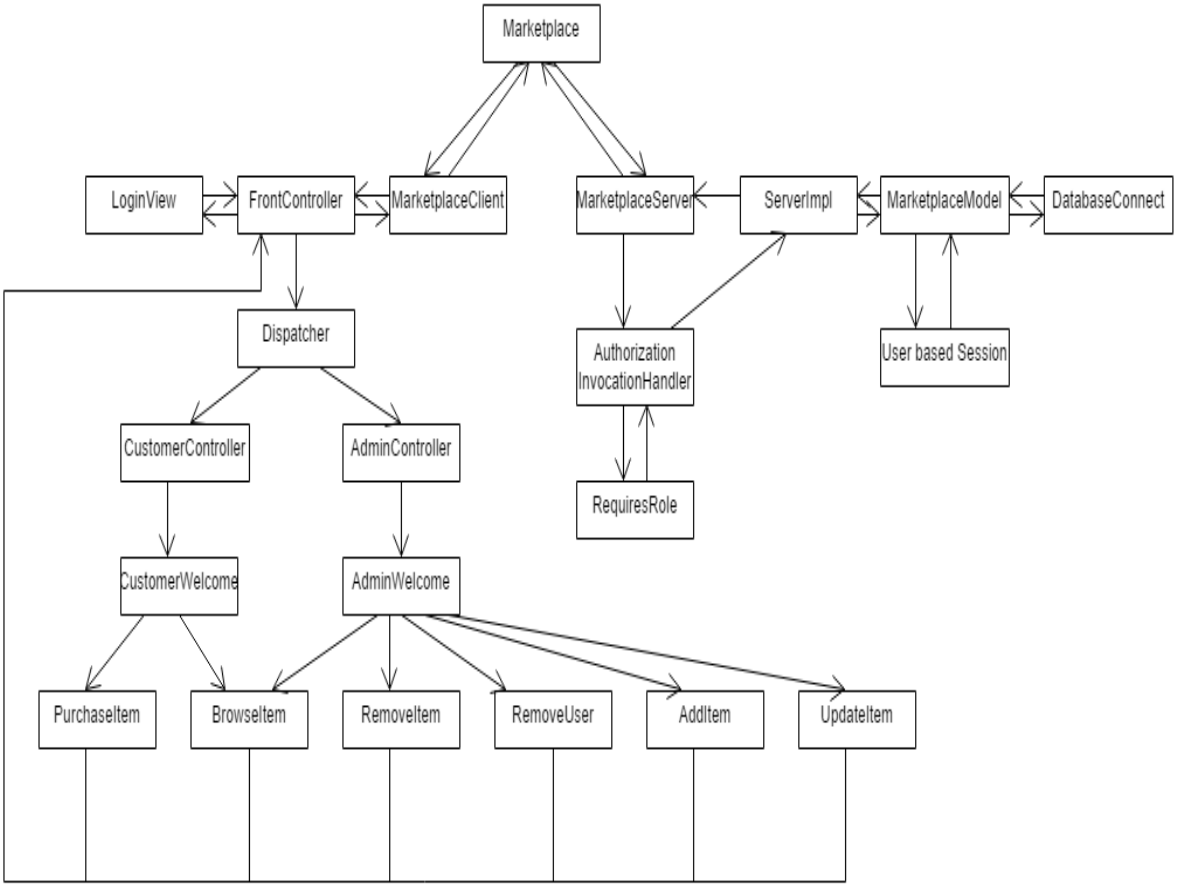
```
public synchronized String purchaseItem(int item_index, int item_quan){
        String message = null;
        try{
            Connection conn = dbConnect();
            int item_quantity = selectProduct(conn, item_index);
            item_quantity=item_quantity-item_quan;
            if(item_quantity >= 0){
                updateQuantity(conn, item_quantity, item_index);
                message = "\nProduct purchase successful!!";
            }
            else{
                message = "\nSorry not enough product left!!";
            }
            conn.close();
        }
        catch(SQLException e)
        {
            System.out.println(e);
        }
        return message;
}

private int selectProduct(Connection conn, int item_index){
        DatabaseConnect db = new DatabaseConnect();
        int item_quantity = db.selectProduct(conn, item_index);
```

```
                return item_quantity;
}

private void updateQuantity(Connection conn, int item_quantity, int item_index){
                DatabaseConnect db = new DatabaseConnect();
                db.updateQuantity(conn, item_quantity, item_index);
}
```

The purchaseItem is a public method which calls two private methods selectProduct and updateQuantity. The synchronization is put on the purchaseItem. It will acquire the lock and implement the private methods. The private methods will not worry about the acquiring locks and perform the execution. The lock will be released by the purchaseItem when both the private methods have completed their execution.

10 Complete Functionality Implementation

Below is a simplified software design model as of this moment:



All the required functionalities have now been implemented. The sample runs for all function can be found in the next section.

11 Sample Runs

Please find below the snapshots to verify that all the functionalities are working:

Signup

-Customer

```
Welcom to Market App...
What would you like to do today?
Please enter your selection:
1. Signup as a new customer
2. Already a user? Signin
1

Please enter a First Name: Mona

Please enter a Last Name: Mona

Please enter a username: mona

Please enter a password: mona
User registered successfully!!

Please enter your Username and Password to sign in.

Please enter a username:
```

☐	Edit Copy Delete	lm	lm	lmodi	lmodi	admin
☐	Edit Copy Delete	monica	s	mon	mon	customer
☐	Edit Copy Delete	Mona	Mona	mona	mona	customer
☐	Edit Copy Delete	Monu	Monu	monu	monu	customer

Login:

-Admin

```
Please enter your Username and Password to sign in.

Please enter a username: admin

Please enter a password: admin
Admin Authenticated Successfully.
Welcome Admin, Below are the items on sale...
```

-Customer

```
Please enter your Username and Password to sign in.

Please enter a username: customer

Please enter a password: customer
Customer Authenticated Successfully.
Welcome Customer, Below are the items on sale...
```

Admin functionalities:

-Manage user accounts

- Add admin

```
1
Please make your selection:
1. Add Account
2. Remove Account
3. Exit
1

First Name: Bran

Last Name: Upp

username: bran

password: upp

Roletype (customer or admin): admin

 Add more users? Please enter 'y' or 'n': n

Users added successfully!!...
```

	firstname	lastname	username	password	roleType
Edit Copy Delete	admin	admin	admin	admin	admin
Edit Copy Delete	Bran	Upp	bran	upp	admin

- Add customer

```
First Name: Brice

Last Name: Ran

username: brice

password: brice

Roletype (customer or admin): customer

 Add more users? Please enter 'y' or 'n': n

Users added successfully!!...
```

- Remove customer

```
username: brice

 Delete more users? Please enter 'y' or 'n': n

Users deleted successfully!!...
```

-Browse Products

```
Please make your selection:
1. Manage Admin and Customers
2. Browse Products
3. Add Products
4. Update Products
5. Delete Products
6. Exit
2

Item id: 8
Name: Dell Simple
Description: Nice Laptop
Quantity: 9
Price per item: 900.0


Item id: 9
Name: VR Laptop
Description: VR Lap
Quantity: 1
Price per item: 900.0


Item id: 10
Name: Dell Laptop
Description: Cool Laptop
Quantity: 10
Price per item: 900.0
```

-Add Products

```
Please make your selection:
1. Manage Admin and Customers
2. Browse Products
3. Add Products
4. Update Products
5. Delete Products
6. Exit
3

Please enter the name of the product: Fly Laptop

Please enter the description of the product:Nice Product

Please enter the quantity of the product:10

Please enter the price of the product:950

 Add more products? Please enter 'y' or 'n': n
\Added products successfully...Browse available products\n
```

```
Item id: 9
Name: VR Laptop
Description: VR Lap
Quantity: 1
Price per item: 900.0


Item id: 10
Name: Dell Laptop
Description: Cool Laptop
Quantity: 10
Price per item: 900.0


Item id: 11
Name: Dell Laptop
Description:  Cool Laptop
Quantity: 58
Price per item: 800.0


Item id: 12
Name: ABC
Description: hghjg
Quantity: 6
Price per item: 600.0


Item id: 13
Name: Fly Laptop
Description: Nice Product
Quantity: 10
Price per item: 950.0
```

-Update Products

```
Quantity: 58
Price per item: 800.0

Item id: 12
Name: ABC
Description: hghjg
Quantity: 6
Price per item: 600.0

Please make your selection:
1. Manage Admin and Customers
2. Browse Products
3. Add Products
4. Update Products
5. Delete Products
6. Exit
4
Please enter the Id of the product you want to update: 10
Please enter the name of the product: Dell Laptop
Please enter the description of the product:Cool Laptop
Please enter the quantity of the product:10
Please enter the price of the product:900
 Update more products? Please enter 'y' or 'n': y
Please enter the Id of the product you want to update: 8
Please enter the name of the product: Dell Simple
Please enter the description of the product:Nice Laptop
Please enter the quantity of the product:9
Please enter the price of the product:900
 Update more products? Please enter 'y' or 'n': n
Update Successful...Browse available products
```

```
Please make your selection:
1. Manage Admin and Customers
2. Browse Products
3. Add Products
4. Update Products
5. Delete Products
6. Exit
2

Item id: 8
Name: Dell Simple
Description: Nice Laptop
Quantity: 9
Price per item: 900.0


Item id: 9
Name: VR Laptop
Description: VR Lap
Quantity: 1
Price per item: 900.0


Item id: 10
Name: Dell Laptop
Description: Cool Laptop
Quantity: 10
Price per item: 900.0
```

-Delete Products

```
Please make your selection:
1. Manage Admin and Customers
2. Browse Products
3. Add Products
4. Update Products
5. Delete Products
6. Exit
5

Please enter the Id of the product you want to delete: 12

 Delete more products? Please enter 'y' or 'n': n
Successfuly deleted Items...
```

```
Item id: 10
Name: Dell Laptop
Description: Cool Laptop
Quantity: 10
Price per item: 900.0


Item id: 11
Name: Dell Laptop
Description:  Cool Laptop
Quantity: 58
Price per item: 800.0


Item id: 13
Name: Fly Laptop
Description: Nice Product
Quantity: 10
Price per item: 950.0
```

Customer Functionalities

-Add item to cart

```
Please make your selection:
1. Add item to Cart
2. Purchase Item in your Cart
3. Browse Products
4. View Products in your Cart
5. Exit
1

Enter the product Id you want to add to cart: 8

Enter the Quantity you want to add: 2
Items in your Cart:

Item id: 8
Name: Dell Simple
Description: Nice Laptop
Quantity: 2
Price per item: 900.0
```

-Purchase Items in cart

```
Please make your selection:
1. Manage Admin and Customers
2. Browse Products
3. Add Products
4. Update Products
5. Delete Products
6. Exit
2

Item id: 8
Name: Dell Simple
Description: Nice Laptop
Quantity: 9
Price per item: 900.0


Item id: 9
Name: VR Laptop
Description: VR Lap
Quantity: 1
Price per item: 900.0


Item id: 10
Name: Dell Laptop
Description: Cool Laptop
Quantity: 10
Price per item: 900.0
```

```
Please make your selection:
1. Add item to Cart
2. Purchase Item in your Cart
3. Browse Products
4. View Products in your Cart
5. Exit
2
=======Your shopping cart Items have been purchased=========
Congrats your order has been shipped...
View more products to buy

Item id: 8
Name: Dell Simple
Description: Nice Laptop
Quantity: 7
Price per item: 900.0
```

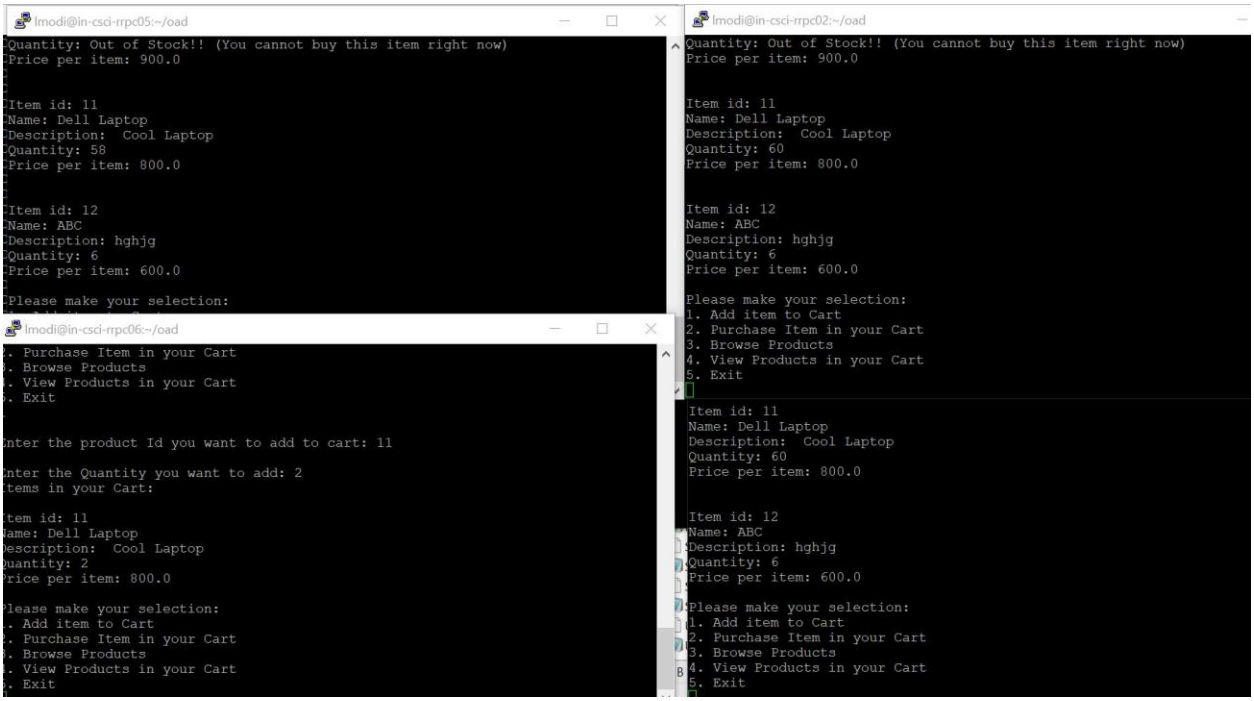
-Browse items

```
Please make your selection:
1. Add item to Cart
2. Purchase Item in your Cart
3. Browse Products
4. View Products in your Cart
5. Exit
3

Item id: 8
Name: Dell Simple
Description: Nice Laptop
Quantity: 7
Price per item: 900.0


Item id: 9
Name: VR Laptop
Description: VR Lap
Quantity: 1
Price per item: 900.0
```

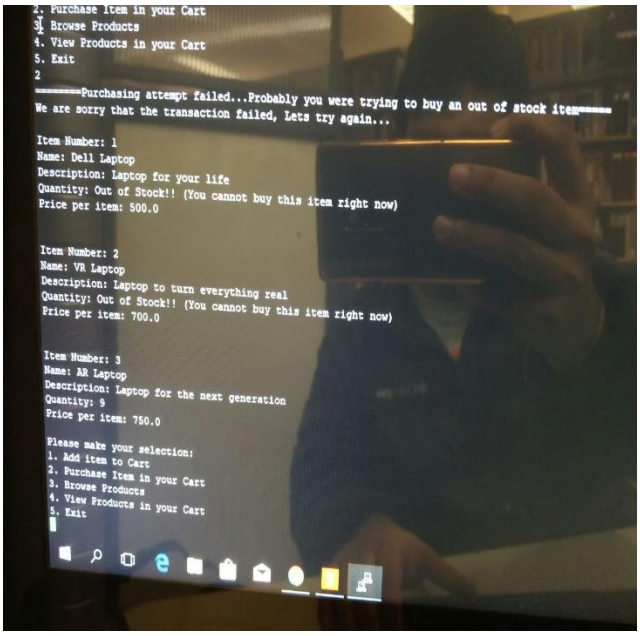
-View Products in cart

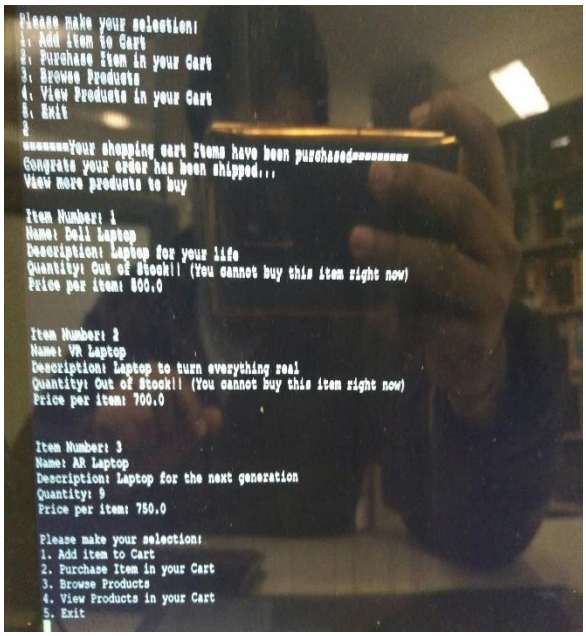
```
Please make your selection:
1. Add item to Cart
2. Purchase Item in your Cart
3. Browse Products
4. View Products in your Cart
5. Exit
4
Items in your Cart:

Item id: 8
Name: Dell Simple
Description: Nice Laptop
Quantity: 2
Price per item: 900.0
```

-Concurrency (4 Clients in parallel)



-Synchronization (Only 1 product left to buy)





12 Conclusion

During this project many design patterns were used to make this application highly scalable, reliable and robust. To implement client server architecture, I used Java's RMI (Remote method invocation) framework.

A conscious decision to use the Model View Control (MVC) architecture for this application to provide separation of concerns and apply the layers design pattern. This helped in developing a low coupled system. Separating the page views from the method implementation helped in keeping the client-side light weight. I have kept view on client side and model on server side and controllers on both client and server sides (marketClientController and marketServerController) so that RMI could be absorbed within the MVC architecture. Market interface has been implemented for the RMI. This separation of concerns ensures that changes in one part of the system do not need changes beyond that subsystem.

Front Controller pattern was implemented in the next assignment. It is the centralized point of entry for all the requests from the client. A dispatcher class was implemented to fetch the required view for the client. All the requests from the views are configured to reach the client controller only through the front controller. Front Controller becomes the pipe line between the client and rest of the system. This has given a great way to control and navigate requests regarding different views.

Role Based Access Control (RBAC) was the crux for the next assignment. RBAC guarantees that a method will be accessed by the user (customer/admin) who has the permission to access that method. This provides security against any malicious attacks trying to access methods which they don't have access to. Authorization Invocation handler is used to get this implemented. It checks whether the user role allows access to a specific method.

Concurrency was the focus for the next assignment. Marketplace application is accessed by multiple clients on a single server. This removes the scenarios when dirty data gives the user incorrect information when two or more threads are working concurrently to modify data. To ensure that it is important to implement synchronization patterns. In my application as per my design I have used thread-safe synchronization and monitor object synchronization. There was no need for future pattern in my application, so it was not implemented.

The implementation of these patterns has helped make robust, reliable, scalable system easy to manage and maintain. Changes in view will not affect the implementation. Even in a distributed environment where there are multiple client calls the application will be easily able to handle it. The implementation on client side is light weight. All the processing is done on the server side making it easy at the presentation layer. The system has less coupling and a fair amount of cohesion. From the security point of view also the application will not provide access to unauthorized users and will not let user access methods they are not allowed to access. This case study has also helped understand when and how to use a design pattern and most importantly when not to use what pattern.