Java and Object Oriented Software Engineering
Semester 2 Coursework Laboratory 2
JAgora - An Electronic Stock Exchange

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1 Coursework Overview and Working Arrangements

During the course of semester 2 you will work on the development of a single software project. Each laboratory will concentrate on a different aspect of the software development process:

Laboratory	Week	Beginning	Topic	Marks
1	19	26th Jan	Warm up	0
2	21	9th Feb	Problem domain analysis	25
3	23	23rd Feb	Unit and acceptance test harness	25
4	25	9th Mar	Design and implementation	25
5	27	23rd Mar	Applying design patterns	25

During semester 2, we will be using *pair programming* to improve the quality of software produced during the laboratories. You should prepare for your scheduled laboratory as normal, by reading the laboratory sheet problem description and undertaking background research. At the start of the scheduled laboratory, your tutor will pair you with a different student to work with in each of the five JOOSE laboratories. You must work with your assigned partner throughout the scheduled laboratory. Your tutor will monitor how you work as a development team as part of your assessment. Following the laboratory each partner should take a copy of the solution developed thus far and make further independent improvements as desired before submission.
Note: As pair programming is part of the assessment for each laboratory, non-attendance without good cause will result in a loss of all 5 marks available in this category. You must note down the name and matriculation number of your pair programming partner on your submission.

2 Problem Description

A *stock exchange* is a financial system for facilitating the purchase and sale of a large variety of stocks, an activity referred to as *trading*. A stock is a financial instrument with a unique identifier, for example "lemons" or "apples".[1]. All the trading in a single stock on a particular exchange is called a *market*, so if one is talking about the buying and selling of lemons stocks, one would refer to the "market for lemons".

A *trader*, with a particluar identifier ("Alice", "Bob"...) interacts with a stock exchange by placing an order to sell or buy a quantity of stock at a particular price. These may be referred to as *bids* (buy orders) and *offers* (sell orders) respectively. There are many different types of orders that a trader can place, including:

[1] More precisely, these examples are commodities, but the term stock is good enough for our purposes, as we will treat them in the same way.

Market order states that the trader wishes to immediately buy (sell) a specified quantity of stock at the best available price on the market.

Stop order states that the trader wishes to buy (sell) up a specified quantity of stock once the price moves below (above) a stated price.

Limit order states that the trader wishes to buy (sell) a specified quantity of stock, but will not pay more (sell for less) than a limit price. The stock exchange will store the order until it can be executed.

A trader also has the facility to cancel their orders on an exchange. A trader may do this if they perceive that market conditions have changed to the extent that their order no longer makes for good business.

The role of the stock exchange is to collate all the orders from traders. The exchange maintains two sorted lists of orders for each market, called an order book. One order book records all the bids for a stock, the other contains all the offers. The orders are primarily sorted by price, from high to low for bids and low to high for offers. When an order arrives at the exchange it is timestamped, so that orders at the same price can be sorted (earlier orders receive priority).

Periodically, the exchange will try to match compatible buy and sell orders from the respective books in a process referred to as *clearing*. No new buy or sell orders can be received while clearing proceeds. Two orders are compatible when the price that a buyer is prepared to pay for a stock exceeds the price that a seller is willing to offer.

There are several different ways of matching up compatible bids. The simplest mechanism is to only match one buy and sell order at a time. The stock exchange will proceed by finding the highest price a buyer is willing to pay (the *best bid*) and the lowest price a selling is willing to part with stock for (the *best offer*) in all the open orders for a stock. If the best bid is higher than the best offer, a *trade* can be made.

When a trade happens, the buyer will pay the seller for the stocks at the price advertised by the seller. The seller will then transfer the desired quantity of stocks to the buyer. Consequently, traders need to maintain a record of the amount of cash in their possession to pay for stocks and an inventory recording the amount of each stock that they hold at any given time.

If the quantity of stocks in the matched buy and sell order are equal then both orders are said to be have been *filled* and are removed from the order books. However, it is more usual for quantity of stocks in the two orders to not match. When this happens, the smaller quantity order is filled and the amount of stocks traded is deducted from the desired quantity for the larger order, which remains in the order book. A completed trade will be timestamped and stored within the stock exchange as part of an audit trail.

For example, consider a hitherto empty market in which Alice places a sell limit order for 100 lemon stocks at $ 45. Bob places a buy order for 50 lemon stocks at $ 40. Since Bob's best bid is below Alice's best offer, no trade takes place during clearing. If Alice now places another offer for 10 lemons at $ 39, a trade will take place. Bob will pay $ 39 each for 10 lemons stocks ($ 390) and Alice will transfer the stocks to Bob. As Alice's second offer was filled it is removed from the exchange and Bob's bid is reduced by 10, so that he is now willing to pay at most $ 40 dollars for 40 lemon stocks.

A trade will result in at least one order (either the buy, sell or both) being completely filled. Consequently this will cause either the best bid price or best offer price (or both) to change. The stock exchange will then re-check to see if another trade is possible at the new prices. In the example given above, the best offer price reverts to $ 45 after the trade is executed, meaning no more trades take place. This clearing loop will continue until no new trades are possible.

If a trader cannot satisfy a trade for which they have placed an order it is usual for the exchange to impose a penalty, such as a fine, or the trader can be excluded from placing further orders.

3 Task

Working with your partner, you must develop two UML diagrams:

- Develop a UML class diagram to describe the elements of the problem domain in the problem description. The domain model must show the classes of the problem domain, their attributes and behaviours. You should draw appropriate relationships between classes and decorate them appropriately (showing identifiers, arities and stereotypes as appropriate). Once you have developed an initial 'raw' domain model you should also seek to refine it by identifying opportunites for applying inheritance relationships between classes and other improvements.
- Develop a UML activity diagram to describe the clearing algorithm for the stock exchange explained in the problem description. The diagram should show the flow of control for the stock exchange when a period of clearing for all stocks is undertaken. You should include the key activity descriptions, as well as the conditions for each branch identified in the diagram.

Initially, you should sketch solutions for the two tasks on paper or a whiteboard. Once you are satisfied with your solution you can either produce a *neat and legible* hand drawn diagram that can be photographed and uploaded, *or* use an online UML tool to draw the final version of your solution. Several possible tools that you can use are:

- `https://www.draw.io`
- `https://creately.com`
- `https://www.gliffy.com`

4 Assessment

Submissions for this exercise are due by 10am two days after your lab during week 21 (week beginning 9th Feb). If your laboratory is on Monday afternoon, for example, you should submit by 10am on Wednesday morning. If your laboratory is on Friday you should submit by 10am on the following Tuesday. You should submit your solution on Moodle in the appropriate upload slot for the laboratory.

Your submission will be marked on a basis of 25 marks for the assignment. Credit will be awarded for:

section	**marks**
Pair programming	5
Class diagram	
Identification of classes, attributes and behaviours	4
Correct use of associations, decorators, labels and arities	4
Exploitation of inheritance where appropriate	2
Activity diagram	
Identification of key steps and choices	5
Correct use of notation for activities, branches and transitions	3
Correct use of notation for guard conditions	2

Note that attendance at the laboratory is mandatory: any student who does not attend the laboratory and work in a pair without good cause will suffer a 5 mark penalty.

As per the Code of Assessment policy regarding late submissions, submissions will be accepted for up to 5 working days beyond this due date. Any late submissions will be marked as if submitted on time, yielding a band value between 0 and 22; for each working day the submission is late, the band value will be reduced by 2. Submissions received more than 5 working days after the due date will receive an H (band value of 0).