Course Programming Project

DePaul Stock Exchange (DSX)

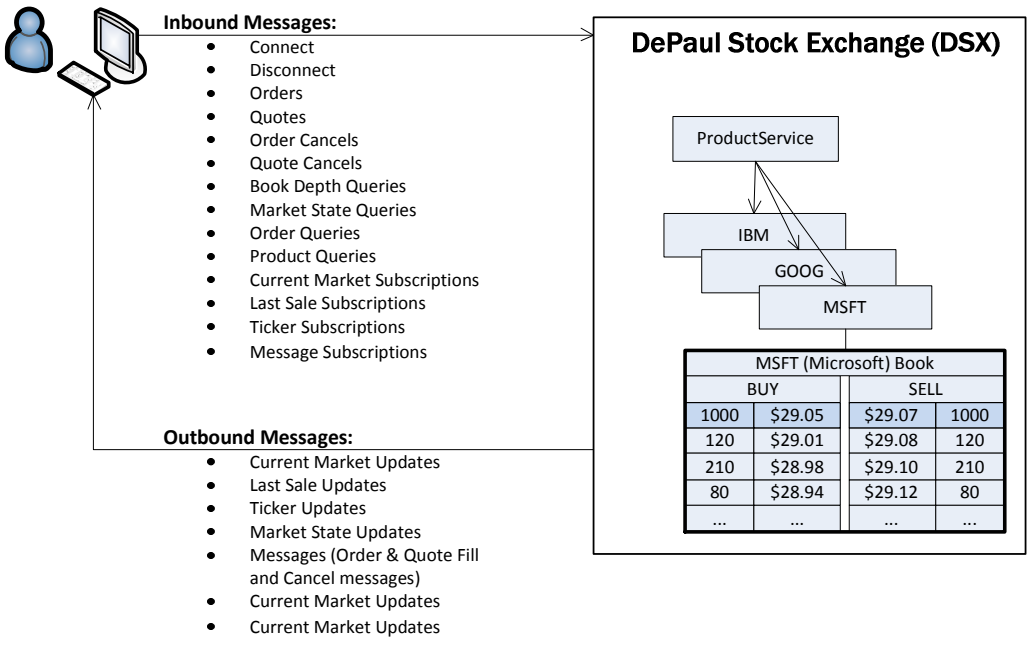
Overview

The Course Programming Project involves creating a stock exchange system that allows users to enter and cancel orders and quotes for listed stocks, and trade (Buy/Sell) these stocks when the prices match.

A "Stock Exchange" is an organized market for the buying and selling of shares of stock in a public company. A share of stock is a tiny piece of a corporation. Shareholders - people who buy stock - are investing in the future of a company for as long as they own their shares. The price of a share varies according to economic conditions, the performance of the company and investors' attitudes. An exchange is like a warehouse in which people buy and sell stocks. A computer must match each buy request to a sell request, and vice versa.

Our application will allow users to login to the "DePaul Stock Exchange (DSX)", and submit orders and quotes to buy and sell a variety of stocks. Users can submit order and quote cancel requests to remove previously submitted orders and quotes that have not yet fully traded. Users will also be able to submit a variety of queries related to the market state, their orders, and tradable products. Users will receive "current market" updates, "last sales" updates and stock "ticker" updates.

The following is a high-level overview of a user's interaction with the DSX system:



Required Terminology:

Understanding the following domain-related terminology will help clarify your understanding of the problem domain and the development requirements of the project:

- **Buy Price** - The highest price that a trader is willing to pay to buy a stock share.
- **Buy Size/Volume** - The number of shares that are available at the bid price. When this number of contracts have been traded, the bid price will move down to the next highest price.
- **Sell Price** - The lowest price that a trader is willing to accept to sell a share
- **Sell Size/Volume** - The number of shares that are available at the ask price. When this number of contracts have been traded, the ask price will move up to the next lowest price.
- **Market Width** - The difference between the best Buy and Sell prices. If a stock's best buy price is $10.00 and its best sell price is $10.08, then the market width (sometimes called the market spread) is $0.08 – 8 cents. Wide markets (i.e., $10.00 - $10.95) are undesirable, as that indicates a large difference between the price buyers are willing to buy at and the price sellers are willing to sell at making trades unlikely
- **Last Sale** - The most recently traded price and volume.
- **Order** –An order is an instruction from customers to buy or sell a number of shares at a stock exchange.
- **Quote** – A quote is an entry in a financial market made up of both a buy and a sell price and volume. "Market Makers" (a special type of trader) insure there is a market for orders by submitting their best buy and a sell prices and volumes. For example, a market maker might indicate that they are willing to buy 100 shares of a stock at $20.45, and are willing to sell 100 shares of a stock at $20.50. These quotes ensure there is a buyer for every sell order and a seller for every buy order at any time.
- **Limit Price** – A specific price specified for an order or for the buy/sell side of a quote (i.e., $10.00, $1.49, etc). Orders and quotes with limit prices will only trade at that price (or better). If a trader submits a limit price order (usually referred to as a "limit order") to buy a number of shares of a stock at $10.00, then that order will only trade at $10.00 or better ("better" for a buyer is a lower price than was requested, "better" for a seller is a higher price than was requested).

- **Market Price** – A non-specific price used to indicate that an order to buy or sell should trade immediately at current market prices. (Note: quotes can never have market prices). As long as there are sellers and buyers, market orders will trade. Market orders are used when certainty of execution is a priority over price of execution. This order type does not allow any control over the price received. The order trades at the best price available at the time.

- **Current Market** – A stock's "current market" is the current best "buy" price/volume and the current best sell price. For example, the current best "buy" price/volume for IBM is 450 shares for $190.02, and the current best "sell" price/volume for IBM is 220 shares for $190.15.

- **Last Sale** – A stock's last sale indicates the price and volume of the most recent trade in that stock. For example, a last sale of 180@$190.59 indicates that someone just traded 180 IBM shares at $190.59.

- **Ticker** – Similar to Last Sale, a stock's ticker indicates the price of the last trade, and usually an indication of whether that price is higher or lower than the previous trade. For example, if IBM just traded at $190.62 – a higher price than the previous trade - the ticker might indicate "IBM $190.62↑".

- **Book** – A stock's "book" (sometimes called "order book") holds the buy and sell orders for a stock that are not yet tradable. The buy-side of the book contains all buy-side orders and quotes that are not yet tradable in descending order. The "top of the book" for the buy-side holds the best buy price in that book (the best buy price is the highest buy price). The "top of the book" for the sell-side holds the best sell price in that book (the best sell price is the lowest sell price). The "book" is often visually represented as follows:

MSFT (Microsoft) Book			
BUY		SELL	
1000	$29.05	$29.07	1000
120	$29.01	$29.08	120
210	$28.98	$29.10	210
80	$28.94	$29.12	80
...	...	...	...

While there is an abundance of material online that can give you a more complete picture of how trading and stock exchanges work, these links cover the basics and might be helpful:

- Trading Basics - Basic Steps in How Stock Trading Works
  http://stocks.about.com/od/tradingbasics/a/Basictrading.htm

- How Stocks and the Stock Market Work
  http://money.howstuffworks.com/personal-finance/financial-plANNing/stocks.htm

Trading Examples:

1) Products start with an empty book – no buy or sell entries are present. Below shows the empty MSFT book:

MSFT (Microsoft) Book			
BUY		SELL	

2) The below reflects the MSFT book after user *LOU* submitted a limit-order to BUY 100 MSFT at $29.90. There is currently no SELL-side market to trade with, so the BUY order is "booked", awaiting SELL-side activity.

MSFT (Microsoft) Book			
BUY		SELL	
100	$29.90		

3) The below reflects the MSFT book after user *ANN* submitted a limit-order to SELL 250 MSFT at $30.05. Since *LOU* wants to buy MSFT at $29.90 but *ANN* is selling MSFT at the slightly higher price of $30.05, the orders do not trade. Both orders are "booked" in the MSFT book.

MSFT (Microsoft) Book			
BUY		SELL	
100	$29.90	$30.05	250

4) The below reflects the entry of a quote by user *UMA*, to BUY 500 MSFT at $29.97 and to SELL 500 MSFT at $30.01. Since the BUY-side of the quote at $29.97 is a better price (higher buy-price is a better price) than user *LOU's* order at $29.90, the BUY-side of the quote is booked *ahead* of *LOU's* order. Likewise, since the SELL-side of the quote at $30.01 is a better price (lower sell-price is a better price) than user *ANN's* order at $30.05, the SELL-side of the quote is booked *ahead* of *ANN's* order. Again, the buy and sell prices do not match so no trade occurs. For the below MSFT book, we would say that the "top" of the book (also called the Current Market) is 500@$29.97 - 500@$30.01.

MSFT (Microsoft) Book			
BUY		SELL	
500	$29.97	$30.01	500
100	$29.90	$30.05	250

5) Next, user *REX* submits a limit-order to BUY 120 MSFT at $30.01. This BUY order's price *matches* the top of the opposite side (the SELL-side in this case) of the book, so a trade occurs: *REX* wants to BUY 120 MSFT at $30.01 and *UMA* is offering to sell MSFT at $30.01. *REX* buys 120 MSFT, leaving no remainder to the order. The order is considered fully filled. User *UMA* sells 120 MSFT, leaving 380 of the original 500 quote quantity. The quote is considered partially filled. The "top" of the book (also called the Current Market) is now 500@$29.97 - 380@$30.01.

MSFT (Microsoft) Book			
BUY		SELL	
500	$29.97	$30.01	380
100	$29.90	$30.05	250

6) Then, user *ARI* submits a "market"-order to SELL 100 MSFT at the current market price. Market orders will trade immediately with the opposite side of the book (the BUY-side in this case) regardless of the price. The current BUY-side price is $29.97 (user *UMA's* quote), so user *ARI's* order will trade at the current market price of $29.97. *ARI* sells 100 MSFT, leaving no remainder to the order. The order is considered fully filled. *UMA* buys 100 MSFT, leaving 400 of the original 500 quote quantity. The quote is considered partially filled. The "top" of the book is now 400@$29.97 - 380@$30.01.

MSFT (Microsoft) Book			
BUY		SELL	
400	$29.97	$30.01	380
100	$29.90	$30.05	250

7) At this point, user *LOU* cancels the order entered earlier (BUY 100 MSFT at $29.90). The order is still booked at it's original quantity, so *LOU*'s order is fully cancelled, and removed from the BUY-side of the book. Since *LOU*'s order was not at the top of the book, the top of the MSFT book does not change. It is still at 400@$29.97 - 380@$30.01.

MSFT (Microsoft) Book			
BUY		SELL	
400	$29.97	$30.01	380
		$30.05	250

8) Now, user *LOU* submits a "market"-order to BUY 500 MSFT. The current SELL-side price is $30.01 (user *UMA's* quote), so user *ARI's* order will trade at the current market price of $30.01. However, the top of the SELL-side book has a quantity of only 380 -- 120 short of the 500 requested by *LOU*. *Remember that market orders will trade with the opposite side of the book regardless of the price.* So, once the best entry in the SELL-side of the book has been fully filled, trading moves to the *next* entry in the book until either the order is fully filled or the entries in the opposite side book have been exhausted. The remaining 120 of *LOU's* order will trade with *ANN's* booked SELL order of 250 at $30.05.

   Therefore, *LOU's* market-order fills at 2 prices: 380 at $30.01 and 120 at $30.05. *UMA's* SELL-side quote is fully filled by this trade (380 at $30.01) so it is removed from the book. *ANN's* order is partially filled (120 at $30.05), so the remainder of 130 remains booked. The "top" of the book is now 400@$29.97 - 130@$30.05.

MSFT (Microsoft) Book			
BUY		SELL	
400	$29.97	$30.05	130

9) Now user *UMA* cancels the remainder of the quote entered earlier (only part of the BUY side of the quote remains: BUY 400 at $29.97). The quote is cancelled, and removed from the BUY-side of the book. All that remain is the partial remainder of *ANN's* SELL order. The "top" of the book is now 0@$0.00 - 130@$30.05 (an empty book-side is reflected as 0@$0.00).

MSFT (Microsoft) Book			
BUY		SELL	
		$30.05	130

10) Finally, user *ANN* cancels the remainder of the order entered earlier (only part of the order remains: SELL 130 at $30.05). The order is cancelled, and removed from the SELL-side of the book. The book is now empty. The "top" of the book is now 0@$0.00 – 0@$0.00.

MSFT (Microsoft) Book			
BUY		SELL	

Phases & Schedule

The Course Programming Project will be implemented in phases, each with a specific duration and due date as is listed below. Detailed documents on each phase will be provided at the beginning of the phase.

Phase 1 (1 Week) 9/17 – 9/24:

- Price & Price Factory

Phase 2 (1 Week) 9/24 – 10/1:

- Tradable & Tradable DTO
- Order
- Quote & Quote Side

Phase 3 (2 Weeks) 10/1 – 10/15: [Midterm 10/8]

- Current Market Publisher
- Last Sale Publisher
- Ticker Publisher
- Message Publisher
- Fill Message
- Cancel Message
- Market Message
- User (interface)

Phase 4 (2 Weeks) 10/15 – 10/29:

- Product Service
- Book & Book Side
- Trade Processor

Phase 5 (1 Week) 10/29 – 11/5:

- User (interface) Implementation
- User Command Service
- Position

Phase 6 (1 Week) 11/5 – 11/12:

- User Interface GUI
- Simulated Traders
- Admin GUI

[Final Exam 11/19]

NOTE: Individual documents will be provided containing the details of each project Phase and its related deliverable.