MA668: Algorithmic and High Frequency Trading Lecture 02

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Managing of Orders

A Matching Engine:
Uses a well defined algorithm that establishes when a possible trade can occur, and if so, which criterion is going to be used to select the orders that will be executed.

A Limit Order Book (LOB):
Keeps track of incoming and outgoing orders.

More on Managing of Orders

1. Most markets prioritize MO's over LO's and then use a price-time priority.

2. If a MO to buy comes in, the buy order will be matched with the standing LO's to sell in the following way:

   A. First, the incoming order will be matched with the LO's that offer the best price (in case of buy order, the sell LO's with the "lowest price").

   B. Then, if the quantity demanded is less than what is on offer at the best price, the matching algorithm selects the oldest LO's, the ones that were posted earliest, and executes them in order, until the quantity of the MO is executed completely.

   C. If the MO demands more quantity than what is offered at the best price, then after executing all standing LO's at the best price, the matching algorithm will proceed by executing against the LO's at the second best price, the third best price and so on, until the whole order is executed.

   D. LO's that have increasingly worse prices are referred to as LO's that are "deeper in the LOB", and the process by which an entering MO executes against standing LO's in the LOB is called "Walking-the-Book".

Alternate Exchange Structures

1. An alternative matching algorithm, such as "pro-rata" rules are used in some exchanges.

2. MO's are matched against posted LO's available at the best prices in proportion to quantities posted *i.e.,* there is no "time-priority" rule.

3. Some markets (for example, in case of futures) mix the two, pro-rata and time-priority.

4. There are a number of other variations in the way exchanges organize offers and trades.

    A. Some markets introduce an additional priority to orders coming from a certain type of trader.

    B. Many exchanges use auctions at particular points in time (such as starting of trading day/closing of market/after trading halt).

Aspects of Transparency

1. An important aspect of characterizing exchange is the degree (and cost) of transparency:

   A. In the US there is a clear legal distinction between regulated exchanges (such as NASDAQ and NYSE) which have specific obligations to publish information regarding the status of LOB's AND other electronic markets (Electronic Crossing Networks (ECNs), dark pools, broker-dealer internalization).

   B. Beyond the legal definitions, we generally distinguish lit (open order book) from dark markets, based on whether LOB information is publicly available or not.

   IMPORTANT NOTE: Throughout the course, "most" of the algorithms are developed on the assumption that agents are trading in the lit market, where they can observe the LOB.

Colocation

1. Exchanges also control the amount and degree of granularity of the information you receive:

   A. You can use consolidate/public feed at low cost.
   B. Pay a relatively much larger cost for direct/proprietary feeds from the exchanges.
   C. They also monetize the need for speed by renting out computer/server space next to their matching engines, a process called "colocation"

2. Through colocation, exchanges can provide uniform service to trading clients at competitive rates.

3. Further, having traders trading engines at a common location owned by the exchange simplifies the exchange's ability to provide uniform service, as it can control the hardware connecting each client to the trading engine: Cable (all have the same cable of same length) and Network.

4. This ensures that all traders in colocation have the same fast access and are not disadvantaged (at least as far as exchange-provided hardware is concerned).

Colocation: Consequences and More

1. Consequences of colocation:

   A. Imposes a clear distinction between traders who are colocated and those who are not.
   B. Those not colocated will always experience a speed disadvantage.
   C. Challenge for regulators, while ensuring that exchanges keep access to colocation as sufficiently competitive.
   D. The issue of distance from trading engine brings us to another key dimension of trading, nowadays (especially in the US equity markets), named fragmentation.

2. US markets have upto 13 lit electronic exchanges and more than 40 dark ones.

3. Question?: What happens to market orders sent to one exchange, if there are better execution prices at other exchanges.

   A. Interaction between multiple trading venues.
   B. Latency when moving between these venues.
   C. Regulations introduce additional dimensions to keep in mind when designing successful strategies.

Extended Order Types

1. The role of time is fundamental in the usual price-time priority electronic exchanges.

2. Traders need to adjust their trading positions very quickly "in response to/in anticipation of" changes in market circumstances, both at the local exchange, as well as other markets.

3. The consequent race to be the "first in/first out" of a certain position, plays a pivotal role in the debate of "benefits VERSUS costs" of "high-frequency trading".

More on Extended Order Types

1. The importance of speed permeates the whole process of designing trading algorithms:

    A. From the actual code.
    B. To choice of programming languages.
    C. The hardware used for implementation.
    D. Characteristic of the connection to the matching engines.
    E. Manner in which orders are routed within an exchange and between exchanges.

2. Exchanges have adapted, and moved well beyond the basic two types of order, namely, MO's and LO's.

3. When coding an algorithm, one must be alert and aware of all the possible types of orders allowed, not only in one exchange, but in all competing exchanges, where the concerned asset is traded.

Some Examples of Types of Orders

1. Some examples of the types of orders a trader may find in exchanges are:

   (A) Day orders: Orders for trading during regular trading sessions, with options to extend to pre/post market sessions.

   (B) Non-routable: Order which, by choice/design avoid the default re-routing to other exchanges.

   (C) Pegged, hide-not-slide: Orders that move with the midpoint or the national best price.

   (D) Hidden: Orders that do not display their quantity.

   (E) Iceberg: Orders that partially display their quantity.

   (F) Immediate-or-cancel: Orders that execute as much as possible at the best price.
   Note: Such orders are not re-routed to another exchange, nor do they walk the book.

   (G) Fill-or-kill: Orders sent to be executed at the best price in their entirety or none at all.

   (H) Good-till-time: Orders with a fixed lifetime built into them, so that they will be canceled if not executed by the expiration time.

   (I) Discretionary: Orders display one price (the limit price) but may be executed at more aggressive (hidden) prices.

Exchange Fees

1. Important note: Trading in an exchange is not free, but the cost is not the same for all traders.

2. Many exchanges run maker-taker system of fees:

   A. Trader sending an MO pays a trading fee (for taking away liquidity from the market).

   B. A trader who posted LO and is filled by the MO (that is the LO with which MO is matched) will pay a lower fee OR even receive a payment (rebate) from the exchange (for providing liquidity or making the market).

3. There are exchanges, where an inverted fee schedule is adopted, namely, a taker-maker system, where the fee structure is the reverse:

   A. Those providing liquidity pay a higher fee.

   B. Those taking liquidity pay a lower fee OR even receive a rebate.

4. Importance of exchange fees: Fees distort observed market prices, with the relevant price being the net price "paid" OR "received".

Limit Order Book

1. We begin with the most basic description of LOB:

   A. Illustrate with an artificial LOB.
   B. Actual example, using detailed message data from two assets, namely, HPQ and FARO (on NASDAQ).
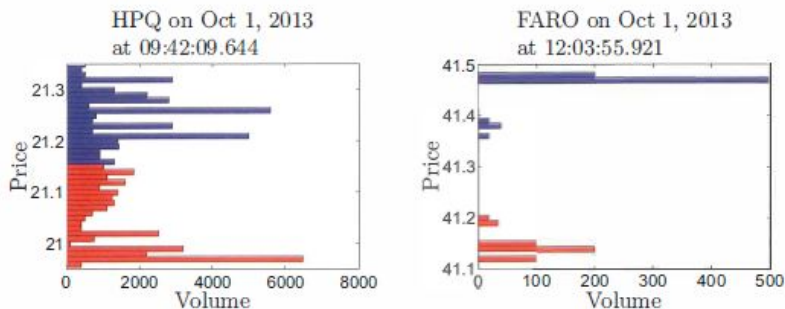
Figure 1.1

Figure 1.1 Snapshots of the NASDAQ LOB after the 10,000th event of the day. Blue bars represent the available sell LOs, red bars represent the available buy LOs.
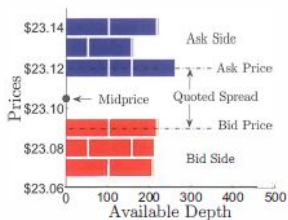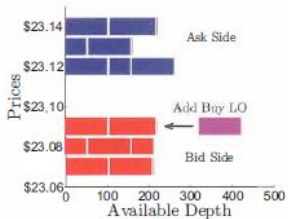
Figure: Figure 1.1

Figure 1.2

Figure 1.2 LOB illustration of a buy LO added to the queue at the best bid.
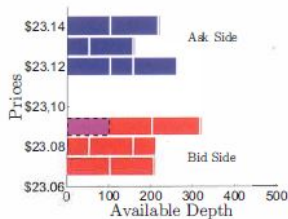
Figure: Figure 1.2

Figure 1.3
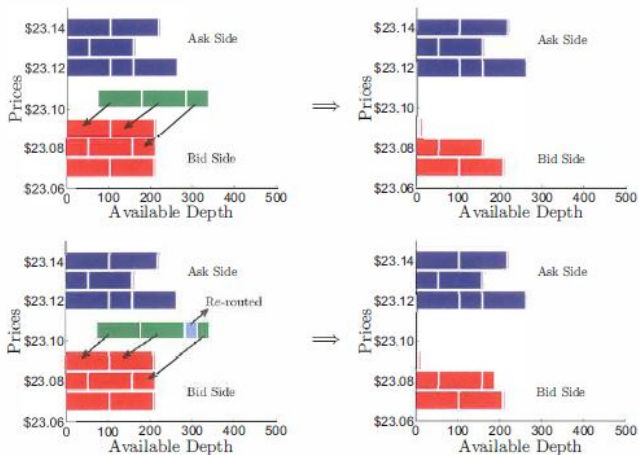
Figure 1.3 LOB illustration of a sell MO walking the LOB with and without re-routing.

Figure: Figure 1.3

Artificial LOB: Addition of LO to LOB

1. Recall: Electronic exchange are fundamentally described by an LOB and a matching algorithm.

2. Price-time priority: An incoming LO joins the LOB at the order's price and is placed last in the execution queue at that price.

3. LO's are displayed as blocks of length equal to their quantities.

4. LO's are ordered in terms of time-priority from right to left.

5. Example: When a buy LO comes in at $23.09 (purple block) it will be added to the line of blocks, already resting at that price.

6. The new LO joins the queue at the point closest to the Y-axis, thereby becoming the third LO waiting to be executed at $23.09.

MO Walks the LOB or is Re-routed

1. Assume that the venue's best bid is the best buy quote that the market, across all venues, currently displays.

2. A new MO (to sell) 250 shares enters the market (sum of green blocks).

3. The matching engine goes through the LOB, matching the existing (posted) LO's (to buy on the bid side) with the entering MO following the rules in the matching algorithm.

4. In the LOB, there are two LO's at the best bid of $23.09 (represented by two red blocks), both for 100 units, thereby, totaling 200 units. The 200 units are executed at the best bid.

5. *Question:* The execution of the final 50 units depends on the order type and the market it is operating in.

MO Walks the LOB or is Re-routed (Contd ...)

1. Standard market: Remaining 50 units will be executed against the LO's standing at $23.08, ordered in terms of time-priority (MO will walk the book).

2. Summary: MO coming in, is split into 3 blocks, the first 2 are matched with LO's at $23.09 and the last with LO's at $23.08.

3. Recall that: In the US, there are order protection rules to ensure that MO's get the best possible execution, and which (depending on the order type) may require the exchange to re-route the remaining 50 units to another exchange, that is also displaying the best bid price of $23.09.

4. In that case, a part of the remaining 50 units (the light blue block) is re-routed to another venue(s) with liquidity posted at $23.09.

5. Only once all liquidity at $23.09 in all exchanges are exhausted, can the remaining shares of the MO return and be executed in this venue, against any LO resting at (the worse price of) $23.08.

6. In the example, 25 units were re-routed to alternate exchanges, and 25 units returned to the venue and walked the book.

MO Walks the LOB or is Re-routed (Contd ...)

1. The MO could, in-principle, be an Immediate-or-Cancel (IOC) order, which specifies that the remaining 50 shares, that cannot be executed at the best bid, should be canceled entirely.

2. Because of order-protection rules in the US (no such rule in European market) it is seldom observed that in the US, a MO walks the book straight away.

3. Rather, it may be observed that a MO is chopped up and executed sequentially in several markets in a very short span of time.