Introduction to Execution Strategies

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Algorithmic Trading

DEFINITION [1]

- **An algorithm is a specific set of clearly defined instructions aimed to carry out a task or process**
- **Algorithmic trading** or **Automated trading**, also known as **algo trading**, **black-box trading**, is
- … the use of computer programs to follow a defined set of instructions for entering trading orders with the computer algorithm deciding on aspects of the order such as the timing, price, or quantity of the order, …
- … or in many cases initiating the order without human intervention

APPLICATIONS

- Algorithmic Trading is widely used by pension funds, mutual funds, and other buy side (investor driven) institutional traders, to divide large trades into several smaller trades in order to manage market impact, and risk
- Short term traders and other sell side investors/participants (market makers, brokers, etc) also benefit from automated trade execution

Source: Wikipedia, Investopedia

But Why?

1. **Identify and React to Opportunities Faster and Decisively**

2. **Track More Markets Simultaneously**

3. **Reduction in Emotion and Increased Discipline**

But Why?

1. Identify and React to Opportunities faster and decisively

- Each of us has rued missing a trading opportunity just because we weren't staring at the right chart closely enough. Or wasting seconds entering an order manually while the market moved away from us

- Using the speed and reliability of computers, specifically designed to monitor the markets, seek and identify trading opportunities based on the trading rules you've specified—and then send your buy, sell, and even your cancel orders—within fractions of second to given exchanges. And when seconds can mean the difference between a big gain and a huge trading loss, we believe you'll find this a significant advantage

But Why?

2. Track More Markets Simultaneously

- No longer do you have to be glued to your screen, trying to keep up with each instrument or stock at once. Automated Trading gives you the power to monitor dozens or even hundreds of securities at once—and do it more efficiently—than ever before

- It's designed to follow multiple markets for you easily, no matter how complex your trading strategies are, or how precise your trading rules are. That means that you can include multiple conditional entries and exits, profit targets, protective stops, trailing stops, and more in your strategies, and have them all automated simultaneously

But Why?

3. Reduction in Emotion and Increased Discipline

- How often have you missed a trading opportunity simply because you hesitated too long…or watched your profits disappear because you held out for more profits, instead of sticking to your planned exit strategy? Can we ever be sure that we have followed the optimal portfolio and money management techniques?
- There's simply no doubt that emotions can be your worst enemy when trading. Automated Trading helps you combat your emotions by helping you get into the market—and out of it—all based on the historically tested and sometimes adaptive and evolving strategies that you might design.

Q & A

Stylized View of How Markets Work

- Daily trading of a stock on an exchange involves four price points viz. O, H, L, C
- Between these points are a constant flow of bids and offers (Market participants willing to buy (bid) for shares and market participants willing to sell (offer))
- Markets are all about price
- Buyer wants as low a price as possible
- Seller wants as high a price as possible
- For a trade to happen, the person willing to buy and the person willing to sell have to agree on a price
- Market participants place orders stating at what price and how much they are willing to buy or sell

Source: Jay Vaananen, Dark Pools & HFT for Dummies

Orders and Order Book Management

- Orders are trade instructions given by traders to brokers and exchanges: They specify what traders want to trade (whether buy or sell), how much, when and how to trade, and on what terms
- Fundamental building blocks of trading strategies
- The financial markets work like any other: there are sellers and buyers. Owners of shares offer a specified number to market at a particular price (the offer price, or "ask"), while buyers bid for a stated quantity, at a named price. If there is a gap between them (the "bid/ask spread"), then one side has to move up or down for a trade to happen. If no one moves, then both sides remain on the system as "quotes".
- Liquidity in simple terms is the ease with which you can buy or sell whatever it is that you want to buy or sell
- Some orders *offer liquidity* by presenting other traders with trading opportunities
- Other orders *take liquidity* by seizing those opportunities

Source*: Larry Harris, Trading & Exchanges*

Order Book System

SPDR S&P 500 ETF TR TR UNIT

Orders Accepted	Total Volume
1,153,586	7,689,062

	TOP OF BOOK		LAST 10 TRADES		
	SHARES	PRICE	TIME	PRICE	SHARES
ASKS ↑	11,000	180.07	14:42:13	180.03	100
	12,500	180.06	14:42:11	180.02	100
	12,900	180.05	14:42:11	180.01	100
	9,700	180.04	14:42:09	180.01	100
	1,100	**180.03**	14:42:09	180.01	200
BIDS ↓	6,400	**180.02**	14:42:08	180.01	100
	9,700	180.01	14:42:06	180.01	100
	9,600	180.00	14:42:06	180.01	100
	14,700	179.99	14:42:06	180.01	100
	11,500	179.98	14:42:06	180.01	100

- If examining the book vertically, orders are usually sorted in descending order
- Traders use orders to convey their bids and offers (or ask). Bids and asks usually include information about the prices and quantities that traders will accept
- These prices are called the bid and offer (or ask) prices.

Order Book

Size	*Bid*	*Offer*	*Size*
200	50.09	50.10	1,000
1,000	49.95	50.15	200
7,000	49.90	50.20	8,000
3,000	49.85	50.25	500
500	49.80	50.30	1,000

- You want to buy 100 shares and the maximum you'll pay is $50.20
- In a fair and properly functioning market, you, as the buyer would receive the lowest offer
- In this case, unknown to you, the lowest ask is $0.10 lower than your limit, which is a good thing because you get the shares at a lower price
- The system of best bid and best offer would result in a better price for you in this case

Order Book System

- Highest bid price in a market is the best bid
- Lowest offer price is the best offer (or best ask)
- Difference between the best ask and the best bid is the bid/ask spread
- An order *offers/provides liquidity* if it gives other traders an opportunity to trade
- Both buyers and sellers can supply liquidity
- Traders who want to trade quickly *demand liquidity*
- Liquidity: Can be thought of as a service that you can buy or sell

Market Mechanisms

- Two main market mechanisms are auctions and continuous trading
- Auctions are the norm in the primary markets
- During the auction, the order book is usually kept hidden with only an indicative price and volume being shown
- In continuous trading markets, potential buyers notify the other participants of the maximum price at which they are willing to buy (bid), sellers the minimum price at which they are willing to sell (ask)
- At a given instant of time, two prices are quoted: bid price and ask price
- If a buyer comes in with an unconditional order to buy (market order) or with a limit price above the current ask price, he will then make a trade at the ask price with the person with the lowest ask
- Corresponding price is printed as the transaction price
- If the buy volume is larger than the volume at the ask, a succession of trades at increasingly higher prices is triggered until all the volume is executed
- The activity of a market is therefore a succession of quotes (bid and ask) and trades (transaction prices)
- The smallest interval between two prices is fixed for each instrument and is called the tick

Structure of the Order Book

Order Book			
Buy Qty	Buy Price	Sell Price	Sell Qty
500	5250.00	5252.00	1650
750	5249.20	5252.10	50
2200	5249.00	5252.30	600
250	5248.75	5252.40	100
150	5248.70	5252.45	50
1260300	Total Buy Qty	Total Sell Qty	1464250

- Order book: List of all buy and sell 'limit' orders with their corresponding price and volume, at a given instant of time
- When a new order is created (say a buy order) it gets appended to the book if it is below the ask price, or generates a trade at the ask if it is above (or equal to) the ask price
- The dynamics of quotes and trades is the result of the interplay between the flow of limit orders and market orders
- Market orders tend to deplete the order book and increase the bid-ask spread
- Limit orders at prices better than best bid/ask price tend to fill the gap and decrease the bid-ask spread
- The role of market makers (or dealers) is to place buy and sell limit orders in order to provide some liquidity and reduce the average spread, and hence, reduce the transaction costs

Structure of the Order Book

- The way limit orders are placed, meet market orders, or are cancelled leads to interesting dynamics for the order book
- What is the average 'shape' of the order book? i.e average # of shares in the queue at a certain distance from the best bid/ask
- Size of the queue reaches a maximum, away from the best offered price
- Result of two effects
  - Order flow is maximum around the current price
  - Order very near the current price has a larger probability to be executed and disappear from the book

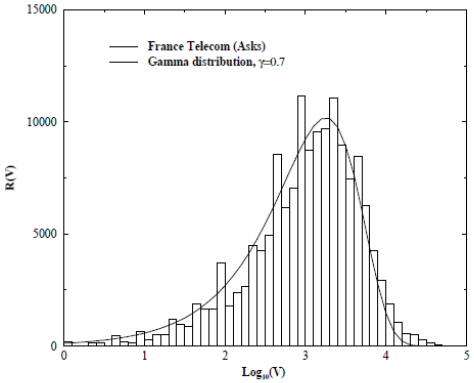


Figure 3: Histogram of the log-volume at the ask (same for bids), for France Telecom. The fit corresponds to Gamma distribution, Eq. (2) (after a change of variables to $\log V$), with $\gamma = 0.7$.

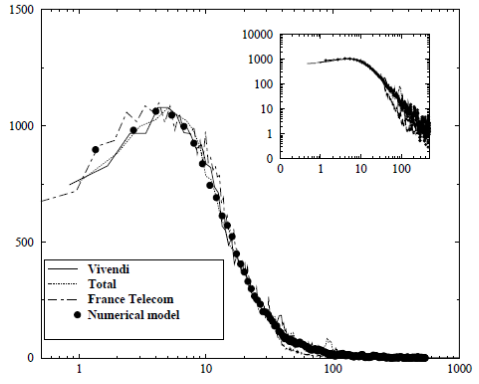


Figure 2: Average volume of the queue in the order book for the three stocks, as a function of the distance Δ from the current bid (or ask) in a log-linear scale. Both axis have been rescaled in order to collapse the curves corresponding to the three stocks. The thick dots correspond to the numerical model explained below, with $\Gamma = 10^{-3}$ and $p_m = 0.25$. Inset: same data in log-log coordinates.

Q & A

Order Routing

- Before technology took over, you would call your broker, who would then call the trading floor, and your order would be executed
- Getting confirmation took minutes, or if you were lucky, tens of seconds
- Now, with direct market access and fast computer algorithms, trades are executed in milliseconds

Order Routing

- Traditionally, orders that come into the market have been placed in *price/time priority* → Best price is always first in line; For orders of equal price, the orders that have come in first are ahead of the queue for that price
- *Price time priority* simply means that any orders coming into a market are prioritized first by price and then by time. The concept has been at the core of exchange markets since inception and it guarantees in an orderly and fair market.
- This is still the way markets are supposed to work but in modern markets, this concept has been tested with different types of special orders used in algorithmic trading models

Price/Time Priority

Size	Bid	Offer	Size
300	50.00	50.10	100
100	49.95	50.15	200
600	49.90	50.20	10,000
500	49.85	50.25	500
100	49.80	50.30	100

Size	Bid	Offer	Size
300	50.00	50.10	100
100	49.95	50.15	200
1,000	49.90	50.20	10,000
500	49.85	50.25	500
100	49.80	50.30	100

- You place an order to buy 400 shares at a limit of $49.90
- The 600 shares that were in the book before will be in front of you if and when they get to be the best bid
- Remember order of importance: first price and then time
- If someone were to come into the market with another order at the same price, s/he would then be put in the queue after you.

Types of Orders

Market Orders

- Execute as quickly as possible a transaction at the best price currently available in the market
- Price of the security is important but secondary to the assurance of getting an execution
- Usually fills quicker but sometimes at inferior prices – used by traders who want to be assured of a fill or sometimes by impatient traders
- *Pays* the bid/ask spread
- Price Improvement: Takes place when a trader is willing to step in front of the current best price to offer a better price to the incoming market order. Lowers the cost of liquidity.
- Traders who submit large market orders often pay more than half the bid/ask spread for liquidity
- Execution is certain but execution price is uncertain

Market Orders

Size	*Bid*	*Offer*	*Size*
300	50.00	50.10	100
100	49.95	50.15	200
600	49.90	50.20	10,000
500	49.85	50.25	500
100	49.80	50.30	100

Size	*Bid*	*Offer*	*Size*
300	50.00	50.15	200
100	49.95	50.20	10,000
600	49.90	50.25	500
500	49.85	50.30	100
100	49.80		

Size	*Bid*	*Offer*	*Size*
300	50.00	50.20	9,800
100	49.95	50.25	500
600	49.90	50.30	100
500	49.85		
100	49.80		

- You want to buy 100 shares now
- You would get those 100 shares at $50.10 per share (plus commission)
- The 100 shares at $50.10 would disappear when your order is matched against it, and the order book would change to reflect the trade
- Suppose you wanted to buy 400 shares, what would happen?

Limit Orders

- Instruction to trade at the best price available, only if it is no worse than the *limit price* specified by the trader
- Primarily deals with the price of the security
- If no trader is willing to take the opposite position at an acceptable price, the order will not get traded
- Limit Orders are on one extreme with control over price but none over time
- Standing limit orders are placed in a file called a limit order book. Depending on the market, a broker, an exchange or even a dealer may maintain the limit order book
- The probability that a limit order will trade depends on its limit price
- If limit price of a buy order is too low, it will not trade
- Buy limit orders with high prices and sell limit orders with low prices are aggressively priced. (Easiest limit orders to fill)
- More complicated than market orders and subsequently may result in higher brokerage fees

Limit Orders

Size	*Bid*	*Offer*	*Size*
300	50.00	50.10	100
100	49.95	50.15	200
600	49.90	50.20	10,000
500	49.85	50.25	500
100	49.80	50.30	100

Size	*Bid*	*Offer*	*Size*
300	50.00	50.10	100
100	49.95	50.15	200
1,000	49.90	50.20	10,000
500	49.85	50.25	500
100	49.80	50.30	100

- You want to buy 400 shares but don't want to pay more than $49.90
- When your order hits the market…
- If a market order were to come to sell 400 shares or a limit order to sell 400 shares @ $49.95

Size	*Bid*	*Offer*	*Size*
1,000	49.90	50.10	100
500	49.85	50.15	200
100	49.80	50.20	10,000
		50.25	500
		50.30	100

Limit Price Placement

- Traders classify limit orders by where they place their limit prices relative to the market
- A marketable limit order is an order that the broker (or exchange) can execute immediately when a trader submits it
- Like market orders, except that they limit the price concessions that brokers can make to fill them
- Traders use marketable limit orders instead of market orders to limit execution price uncertainty and to limit what they will pay for liquidity
- Limit buy orders that stand at the best bid, and limit sell orders that stand at the best ask, are *at the market*

Limit Price Placement	Buy Orders	Sell Orders
Above the best ask	"Marketable"	"Behind the market"
At the best ask	"Marketable"	"At the market"
Between current best bid and best ask	"In the market"	"In the market"
At the best bid	"At the market"	"Marketable"
Below the best bid	"Behind the market"	"Marketable"

Stop Orders

- Used to manage risk
- A stop instruction stops an order from executing until price reaches a *stop price* specified by the trader. Also referred to as *stop loss order*
- Traders attach stop instructions to their orders when they want to buy only after price rises to the stop price or sell only after price falls to the stop price
- Can attach stop instructions to any type of order. Most often attach them to market orders
- Commonly used to stop losses when prices move against their positions
- Price at which stop order executes may not be the stop price
- To guarantee a trade at a particular price, a trader must purchase an option contract

Stop Orders and Liquidity

- Stop orders accelerate price changes
- When price changes activate the stop orders, they may contribute to the one-sided demand for liquidity
- Accelerate price changes by adding buying pressure when prices are rising and selling pressure when prices are falling
- They demand liquidity when it is least available
- *Adds momentum* to the market
- Momentum trading strategies → Buy when prices are rising and sell when prices are falling. This trading destabilizes prices
- Contrarian trading strategies→ Buy when prices are falling and sell when prices are rising. They stabilize prices when they trade. Can be implemented using standard limit orders

Other Types of Orders

- Iceberg Order: Does not show the full amount of the order in the order book: commonly executed using an algorithm
- Fill or Kill Order (FOK): Used when you absolutely have to get the full quantity of an order filled at a specific price
- Immediate or Cancel Order (IOC): Very similar to the FOK. It differs from a FOK, as if only a portion of the volume can be executed, it will be.

Q & A

Special Order Types

- All special order types are derived from the traditional order types which we just saw
- Tend to be orders that can only be executed via computer trading models
- Special order types are constantly being added to and changed
- A couple of aspects of special order types remain constant, regardless of the order type
  - **Hidden volume:** Although the order is active on the market, some or all of the volume isn't visible on the order book.
  - **The way they interact within the bid-offer spread:** The order's position in the order book queue and when it becomes active or visible is dependent on the bid-offer spread.
- Exchanges keep coming up with imaginative ways of combining these two aspects to offer sophisticated traders ways to place orders in the market

Special Order Types

An individual special order type tends to be one or a combination of these three characteristics:

- **Pegged**: The order is based on a benchmark bid-offer and moves when the bid-offer changes
- **Hidden:** Some or all of the volume in the order isn't shown on the order book
- **Post only:** An order designed to gain rebates and add liquidity. If there is a matching order in the market, a post-only order may become less aggressive to control the inventory size while adding liquidity

Strategy Internals

Any Trading Strategy can be seen as Passive or Aggressive or a Combination of the two:

- **Passive Agent** – executes trades at advantageous prices by putting limit orders at Bid (or Ask) to maximize probability of market orders hitting and receiving bid-ask spreads

- **Aggressive Agent** – opportunistically pay bid-ask to the market, based on historical market data as and when beneficial to the execution strategy

Pegging

- Imagine an order, unlike a conventional limit order, automatically updates its price according to movements in quoted price
- Typically a pegged buy order will move along with the “bid”
- Counterparty market orders will take this liquidity, thus increasing “probability” of execution at favorable price
- Pegging can be useful in liquid stocks and fast moving markets

Discretion Order

- They are just regular limit orders, except that they have a second limit price
- This price is called as discretion price at which trader is willing to trade using market orders
- With this, trader maintains benefit of limit order with increased probability of execution
- Selectively Aggressive – that it trades when it is cheapest to do so, when bid-ask spreads are narrow

Q & A

Key Strategy Ideas

- **Trend Following**: Simply identify the trend and ride it; Not bothered with underlying fundamentals of the firm
- **Market Neutral Strategies**: Taking matching long and short positions in different stocks. Two main approaches: fundamental arbitrage and statistical arbitrage.
- **Delta Neutral Strategies**: A portfolio strategy consisting of positions with positive and negative deltas such that the overall delta of all the assets is zero
- **Statistical Arbitrage**: Short-term trading strategy that employs mean reversion models involving broadly diversified portfolios of securities held for short periods of time
- **Market Making**: Trying to make the spread while minimizing inventory risk (by analyzing order flow, side on which more trades are happening, and deciding which way the market might move)
- **Contrarian Strategies** (Is this also trend following?)

Moving towards an Execution Strategy

Let's first define the **Problem Statement**

- A fully ***automated*** system for executing trades of a given financial exchange traded security in such a way that it can ***reliably*** execute within a given ***time frame*** while taking advantage of ***real time*** market movements to realize ***price improvements*** if possible.

So how can this be **Implemented**???

Key Variables and Inputs

- Number of shares
- Time period
  - Sell “x” shares each “n” periods such that total shares to be executed is “nx”

- What will be the Average Price of the executions?

- Will you be happy with such a price?

Are there other variables/ inputs that you can think of?

VWAP

- Commonly used metric in algorithmic trading models is the Volume Weighted Average Price (VWAP)
- As the name suggests, it takes into account the volume of a stock during the trading period which can be seconds, minutes, hours, etc.
- The idea is: If a stock can be bought below VWAP, it's a good price. If above the VWAP, then it's a bad price. Similarly if you sell the security at a price higher than the VWAP then it is a good sell.
- Market makers, institutions, HF traders use VWAP as a benchmark for their trade execution.

Calculation of VWAP

Price	Volume
14.00	1100
14.50	600
14.20	1800
14.35	400

1. Multiply price of each trade by its corresponding volume
2. Add these results together
3. Add all the volumes
4. Divide (2) by (3) to get 14.205

- You can use the VWAP to build a moving VWAP (MVWAP)
- MVWAP is a constantly updating version of the VWAP ex. One-minute VWAP

Summary of an Automated VWAP Strategy

3 key elements a VWAP Strategy

- **Analysis of Incoming orders:** Analysis before a trade, which filters out any orders that can be traded more appropriately using other means. Any trades which are illiquid or very large relative to average daily volume are diverted for manual attention.
- **Intelligent volume distribution:** A key element of a successful automated VWAP strategy is an accurate estimate of the volume distribution. Over the desired time, the system generates a prediction of the stock's volume pattern, full-day or partial-day. To match this projected volume pattern, a trading distribution is created. More trading participation takes place during the periods of the day when volume is expected to be the heaviest, while minimizing the impact of trading during thin volume periods allowing the order to benefit from most liquid conditions.
- **Work orders intelligently:** The last critical element of a successful automated strategy is the ability to obtain best execution on individual trades around the expected volume distribution. A set of rules are used here to balance passive trades & earn spread against the need to stay on schedule for each time period of the day. When markets are most liquid it taps into all available sources and trades most heavily.

Q & A

Order Specifications

- Trading symbol
- Side (Buy/Sell)
- Size (Minimum Size, Maximum Size)
- Price Limits (if any)
- Urgency (Low, Medium, High)
- Time Horizon (Deadlines)
- Any Special Instructions?

Another look at Limit Orders

- In a Limit Order, maximum (minimum) price to buy (sell) is specified
- Passively wait for the market to move in favour
- Such an order type gives complete control over Execution Price, but no control over “when” order will execute
- Limit Orders are on one extreme with control over price but none over time

And Market Orders

- They are used in Aggressive strategies.
- Allows for immediate execution but little control over execution price
- Execution may result in Price Impact –"worsening of execution price relative to current quoted market price"
- Basically market orders results in paying a substantial premium for the right to execute immediately

Why Bother?

- Issue is faced by Mutual Funds, Hedge Funds
- Trading large blocks and cannot afford to send market orders as they would result in market impact and inferior execution price
- Require certain degree of immediacy to complete trades in defined time horizon
- Essentially they require a mix of the two – Blend of Aggressive-Passive Approach

Q & A

Blended Strategy

Blend Pegging and Discretion

- Now one can issue a buy order pegged to bid with 1 Tick Discretion Range

- This will automatically adjust the order price such that it is always equal to current bid and also maintains a discretion range of 1 Tick above the current bid

- Thus order receives advantage of pegging (staying competitive) with the advantage of discretion (trade aggressively to increase probability of execution)

Another View

- Think of blended order being traded by two independent trading agents
- Passive agent maintains an open limit order and pegs to match movements in market
- Aggressive agent watches the bid-ask spread in the market and trades when its narrow
- “Discretion Range” is a measure of aggressiveness of the strategy. If Discretion Range is Zero, then it won’t trade and if its set high, Passive won’t trade most likely

Drawbacks

- Contributes to the momentum which is disadvantageous to the order process
- The strategy gives itself away
- Discretion is cumbersome to use
- Discretion range is static and cannot react to market changes in real time

Momentum how?

- Say the current market is 10.00/10.15
- There are five buyers at 10.00 and a buyer comes in and places an order at 10.10, all buyers go to 10.10. A single movement caused a movement of nearly 1% which might indicate a sudden increase in demand
- Since all buyers are pegged to each others price, they will never lower their price, rather only ratchet it higher
- Similar consistent behavior gives away to other players, pegged strategies

Too many parameters!

- Pegging and Discretion Range – To manage a number of such stocks becomes difficult

- Discretion Range is a measure of aggressiveness – however if one has a time horizon commitment, then to achieve it, manual correction is the only way. Too much or too little becomes the question then

- Especially cumbersome when a number of orders are being worked simultaneously

Now the current problem statement

Method to implement an **order** to trade on an exchange specific security a **specified number** of stocks **within a time horizon** including sending a **first partial order** to trade security having **peg order price**, peg order price and size being **correlated** to current quote and size on the exchange AND a **second partial order** to trade security at a **predetermined amount** better than current market quote for the same side as the order wherein, predetermined amount *(bid-ask spread)* is automatically calculated based on **historical trading data** and **ratio of order completion** with respect to **time horizon**

Terminology

- BID – best quoted bid price
- ASK - best quoted ask price
- BID SIZE – current size quoted at BID
- ASK SIZE – current size quoted at ASK
- SPREAD – “ASK-BID”
- MARKETABLE PRICE – “ASK for buy orders” “BID for sell orders”
- SAME SIDE DEPTH - “BID SIZE for buy orders” “ASK SIZE for sell orders”
- OPPOSITE SIDE DEPTH - “ASK SIZE for buy orders” “BID SIZE for sell orders”
- MORE AGGRESSIVE – for Buy orders, Price x is “more aggressive” than Price y if x>y, for Sell orders, Price x is “more aggressive” than Price y if x<y
- MORE PASSIVE – for Buy orders, Price x is “more passive” than Price y if x<y; for Sell orders, Price x is “more passive” than Price y if x>y
- DEPTH AHEAD – Aggregated Size at all price levels MORE AGGRESSIVE than the order price
- ALONE AT INSIDE – an order is “ALONE AT INSIDE” if order price = BID or ASK and SAME SIDE DEPTH = order size

Conditionalities

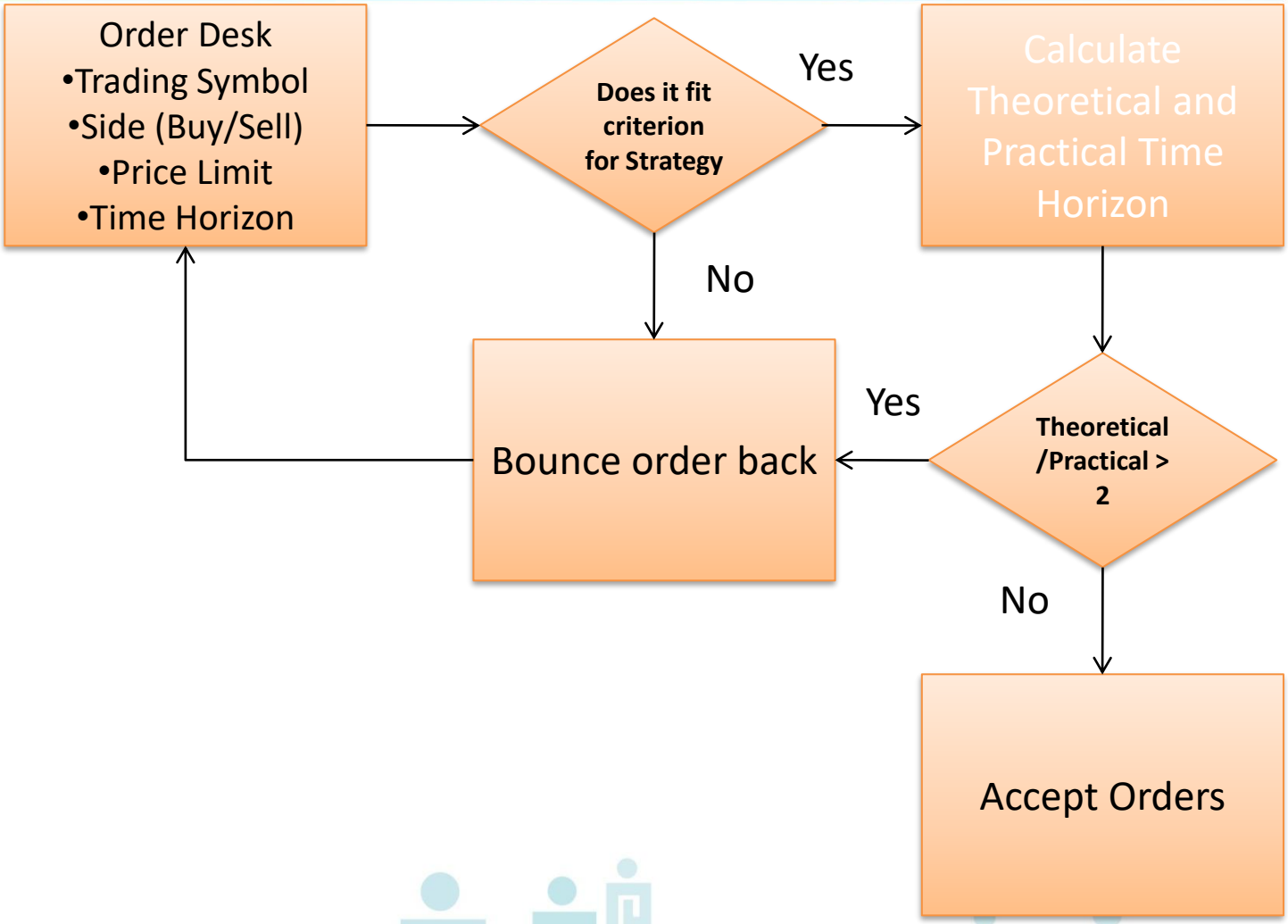
- Pegging to avoid adverse Price momentum
- Pegging to disguise its behavior to avoid exposure
- Dynamic discretion range in aggressive mode
- Still keep the trade on track, time-wise and volume-wise
- If passive agent has been successful at achieving fills at advantageous prices then limited role for aggressive
- If passive is not successful, aggressive intervenes to complete trade on time

Logic at the outset

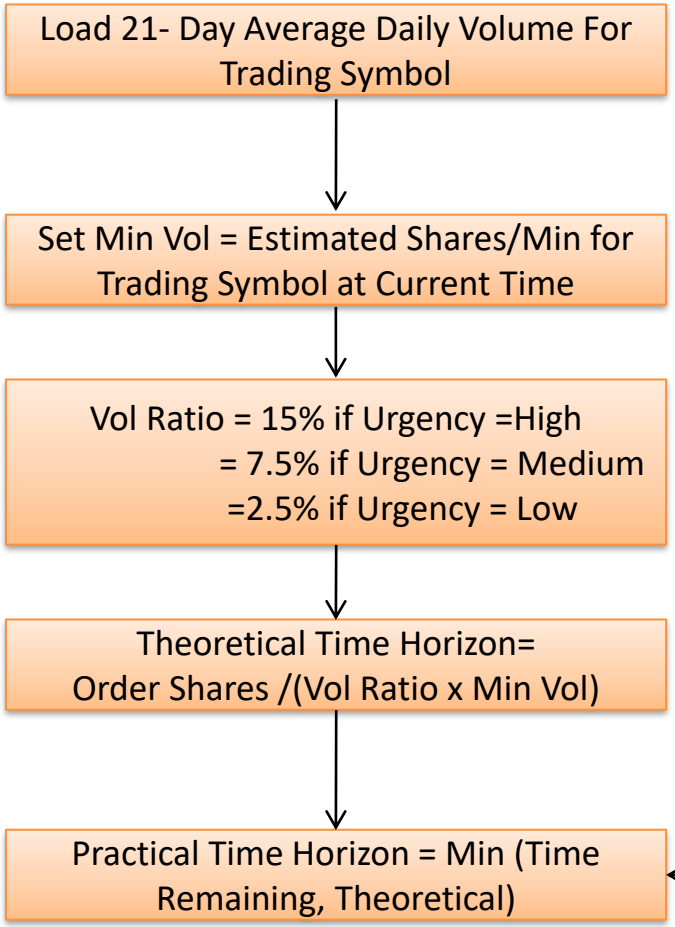
- Order is received with details about trading symbol, side (buy or sell), price limit and time horizon of the trade.
- Price Limit is Optional (Max/Min Limits can be specified)
- Urgency can be specified as Level (High, Medium or Low) or a specific time horizon (e.g. 5 hours)
- If order is greater than or less than a certain size (breakeven size), then it qualifies for the strategy

  For example – daily volume in a given stock is 1 million, order is for 0.75 million (Not feasible)

Logic at the Outset



Calculation for Theoretical/Practical



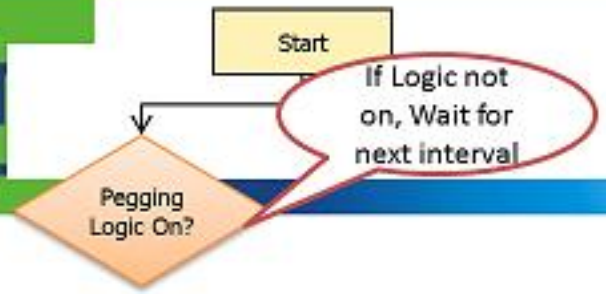
This is broken down by hour of the day ex. 30,000 shares/hour

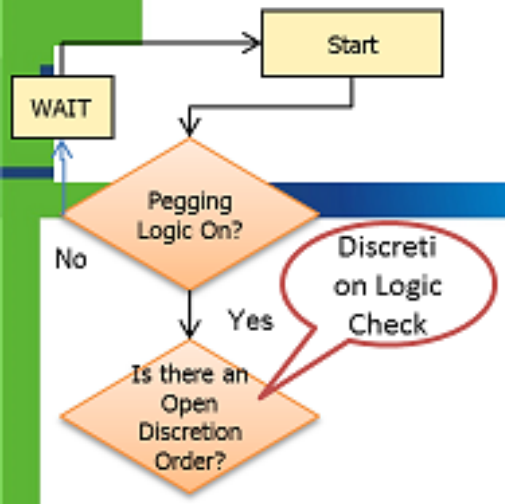
Based on the 21 day average volume→ 500 shares/min

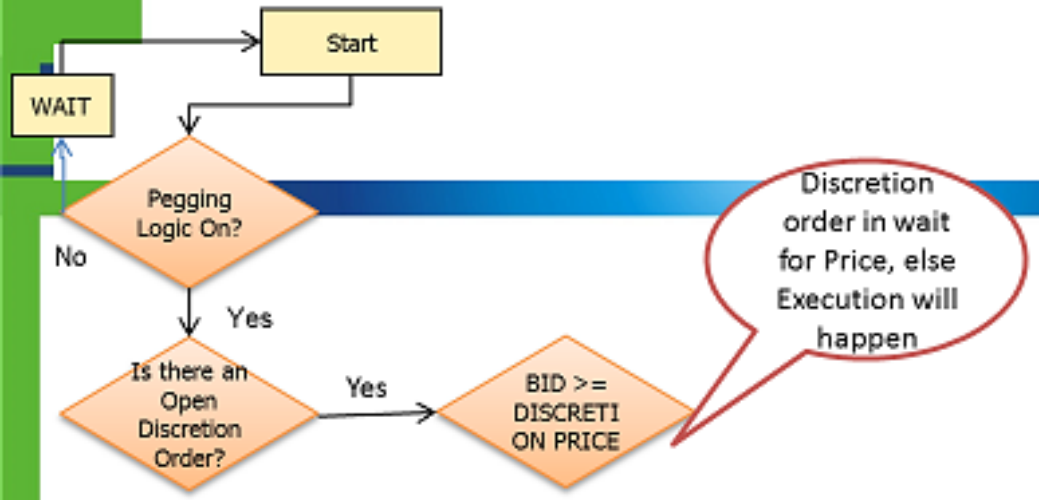
Theoretical/Practical Time Horizon

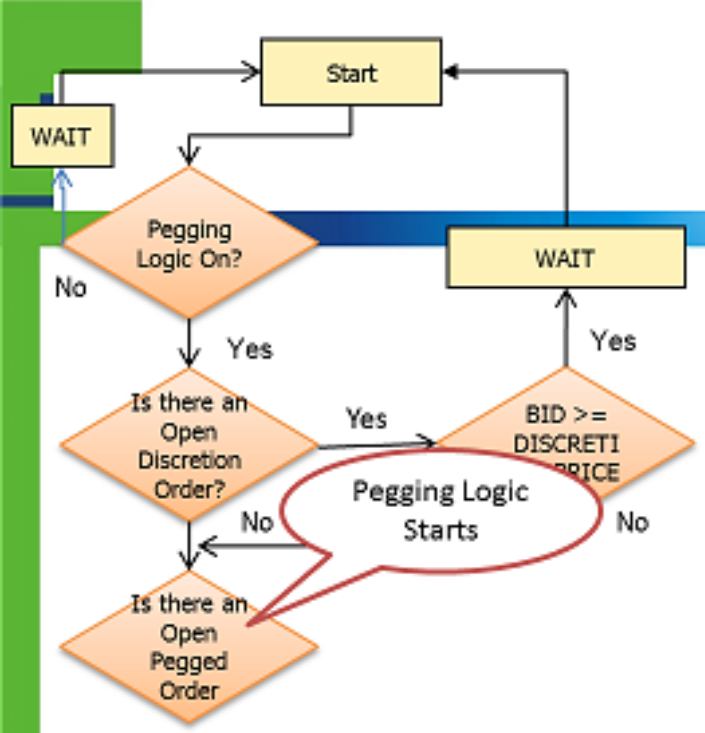
- Theoretical Time Horizon = Order Shares / (VolRatio * MinVol)
- For an order of size 10,000 and if urgency is high, MinVol comes to be 500 shares per minute, TTH = 10000/(0.15*500) = 134 min
- Practical Time Horizon = Min (Time Left, TTH)
- If Max Horizon is 120 min and TTH comes to 134 min, then system uses 120 mins as PTH
- In case TTH/PTH > 2, Time can be deemed insufficient for completion of the trade.

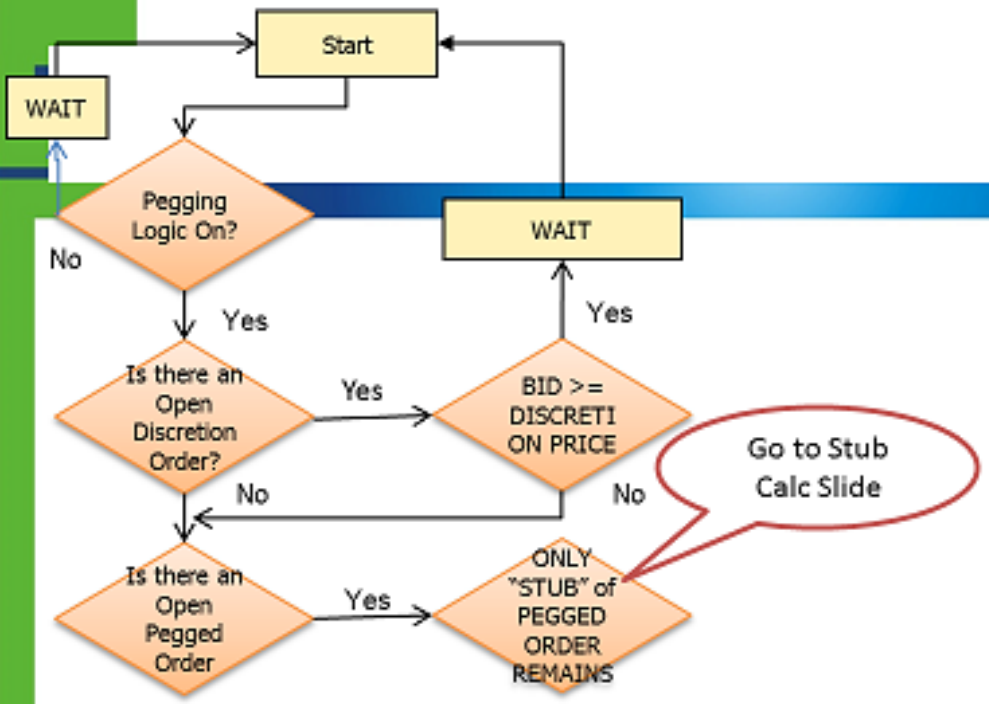
Q & A

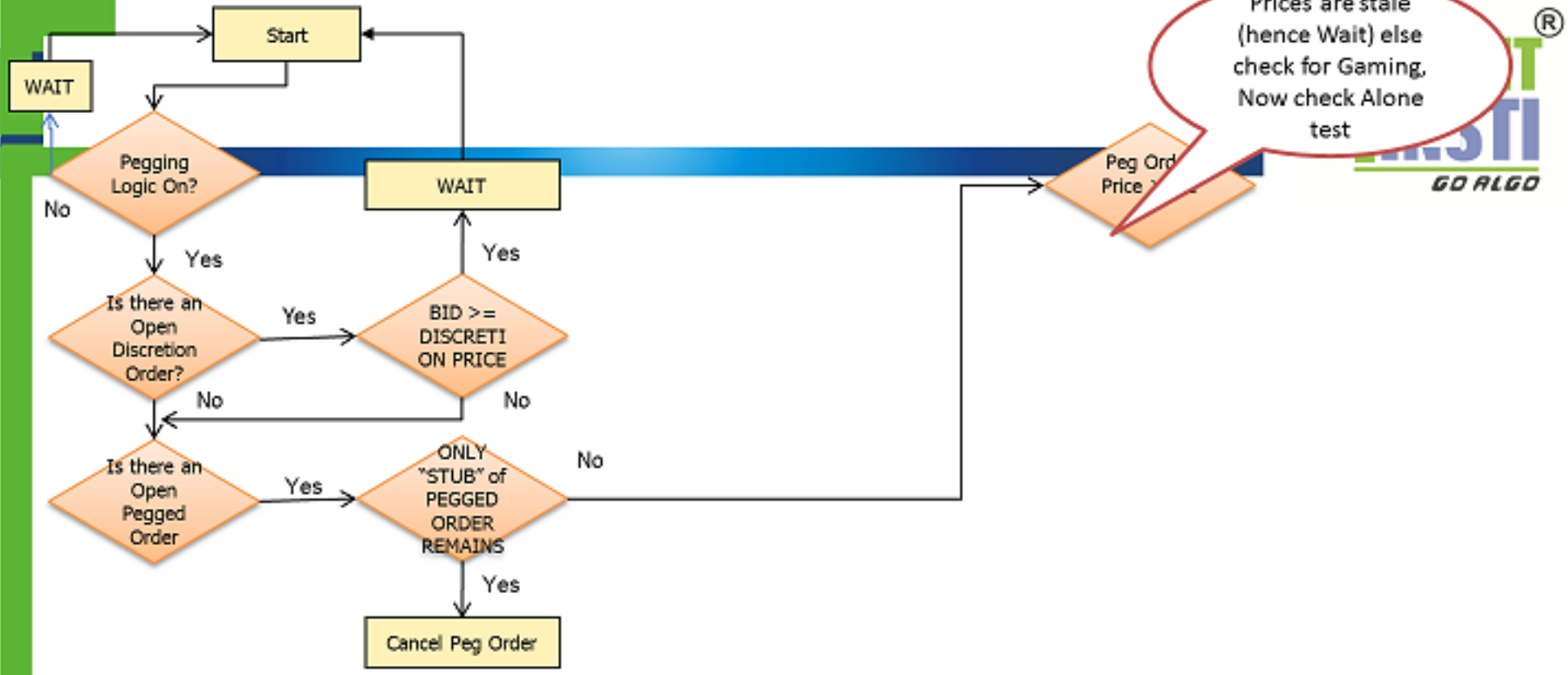


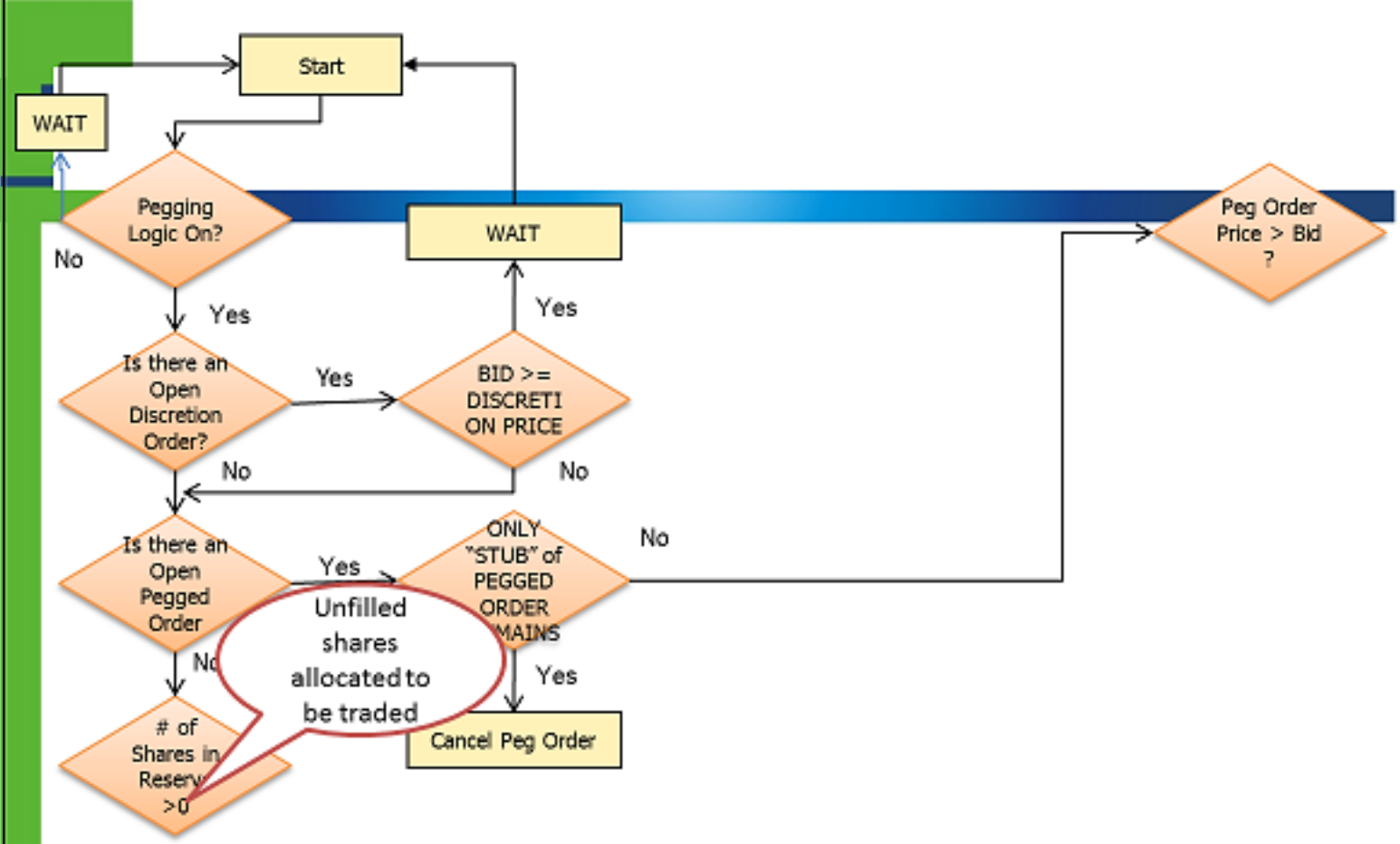


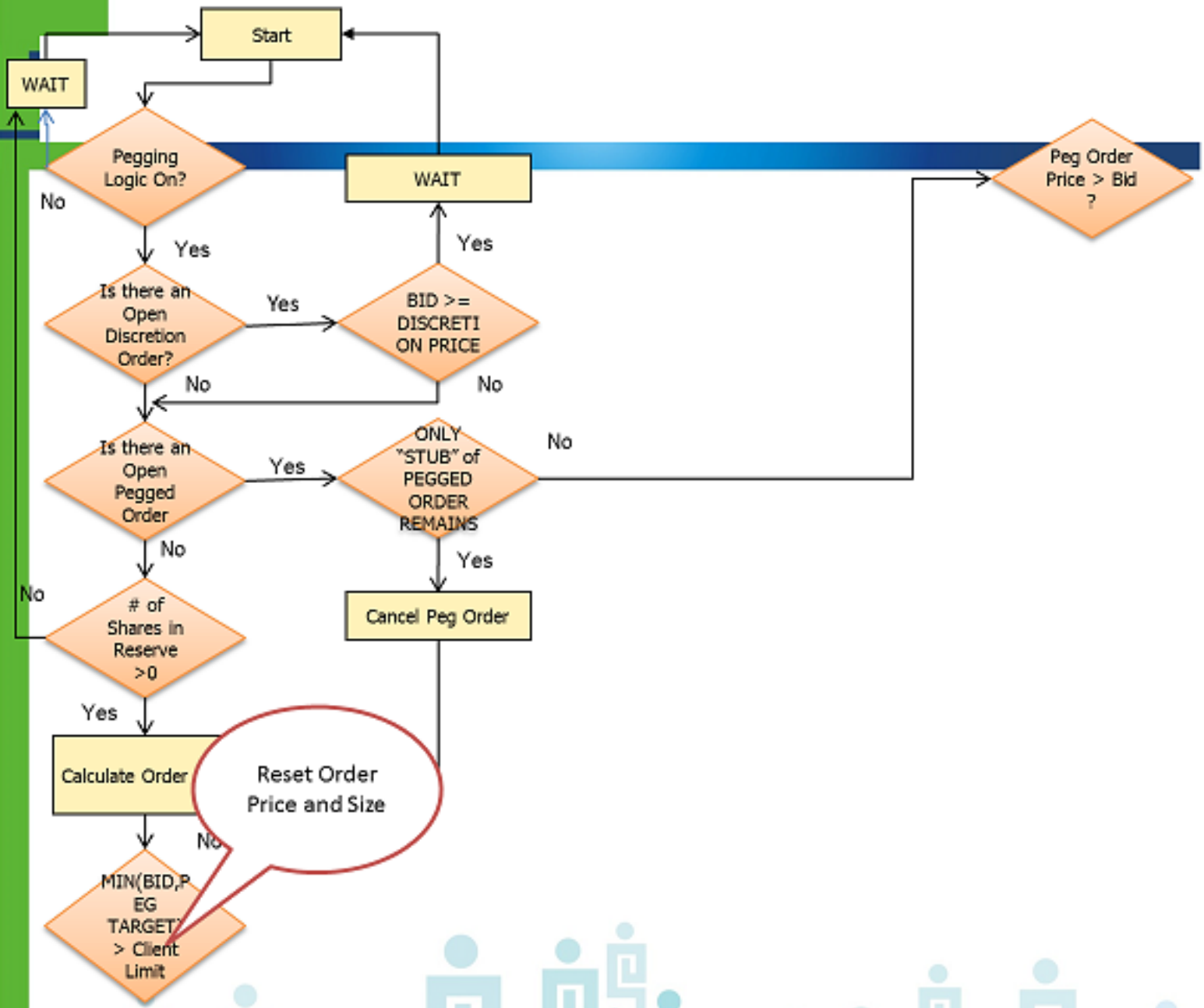


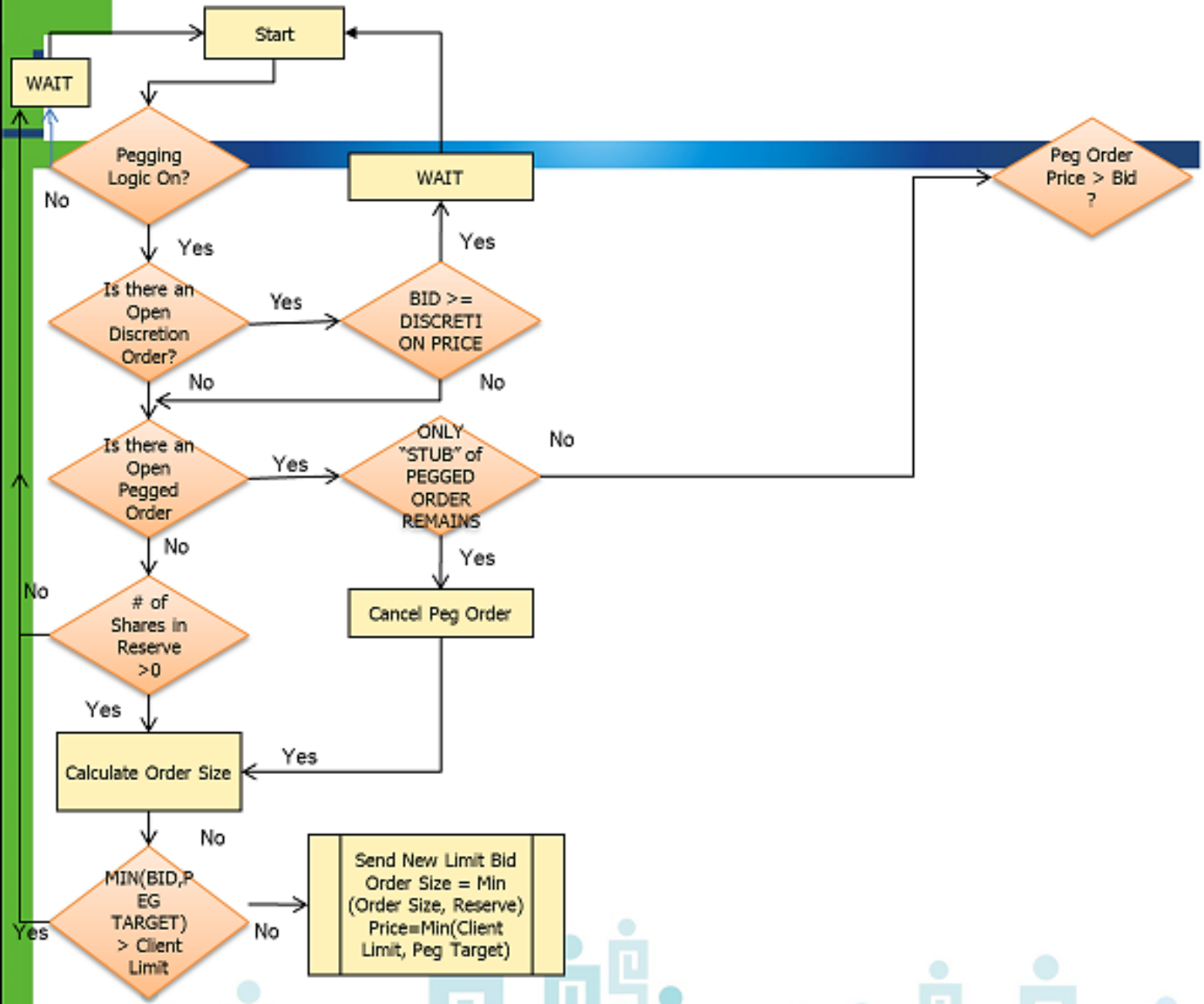


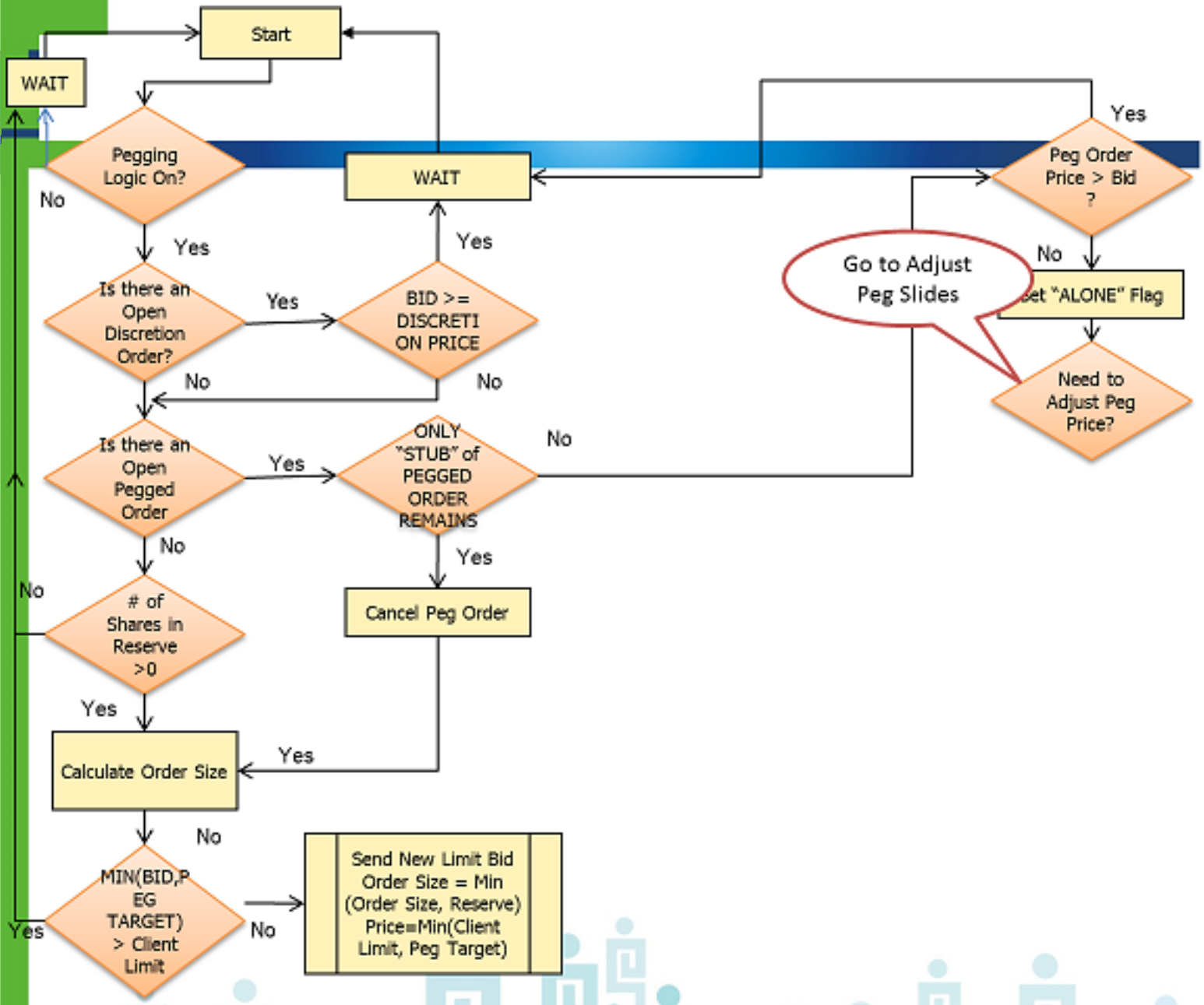


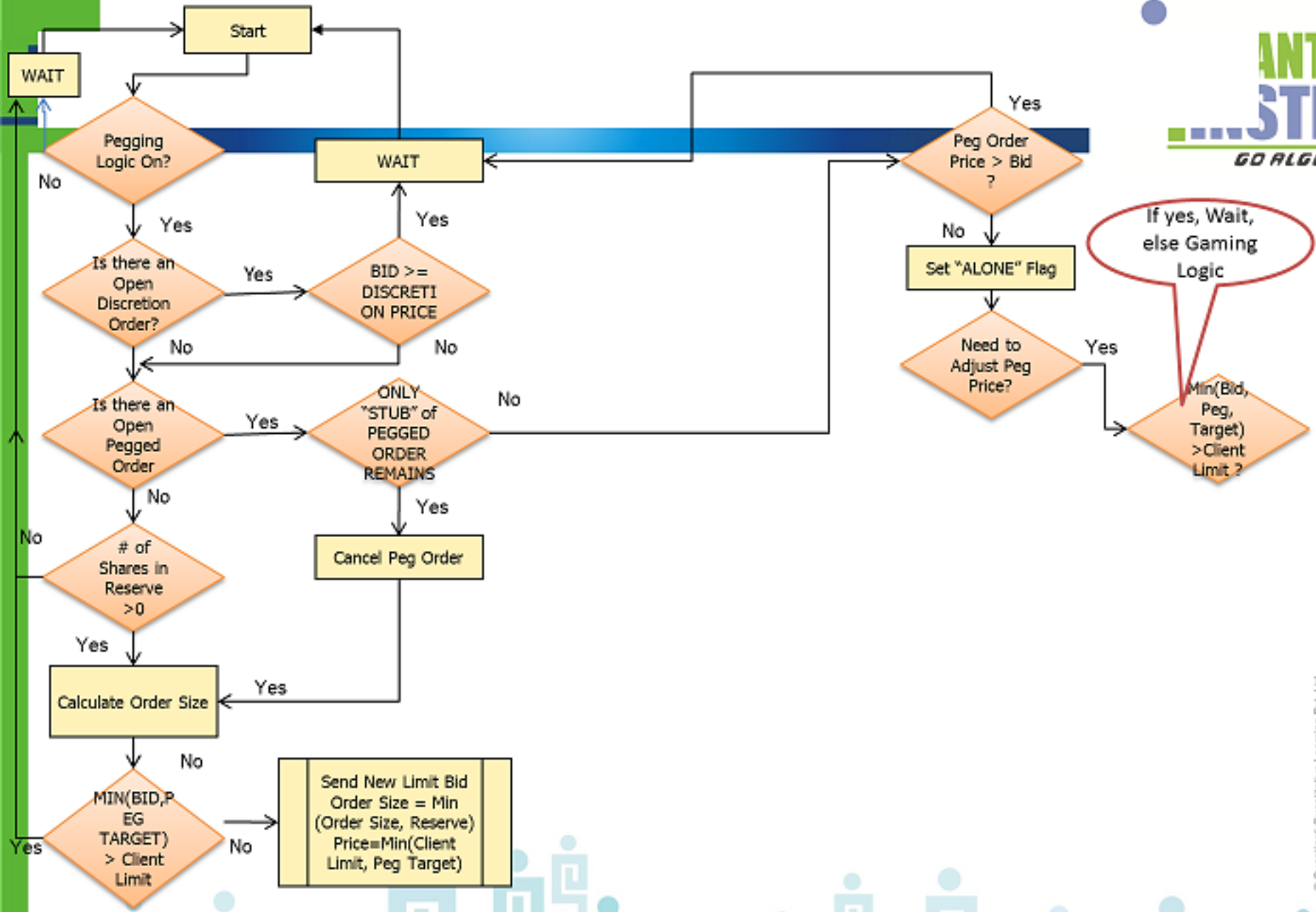


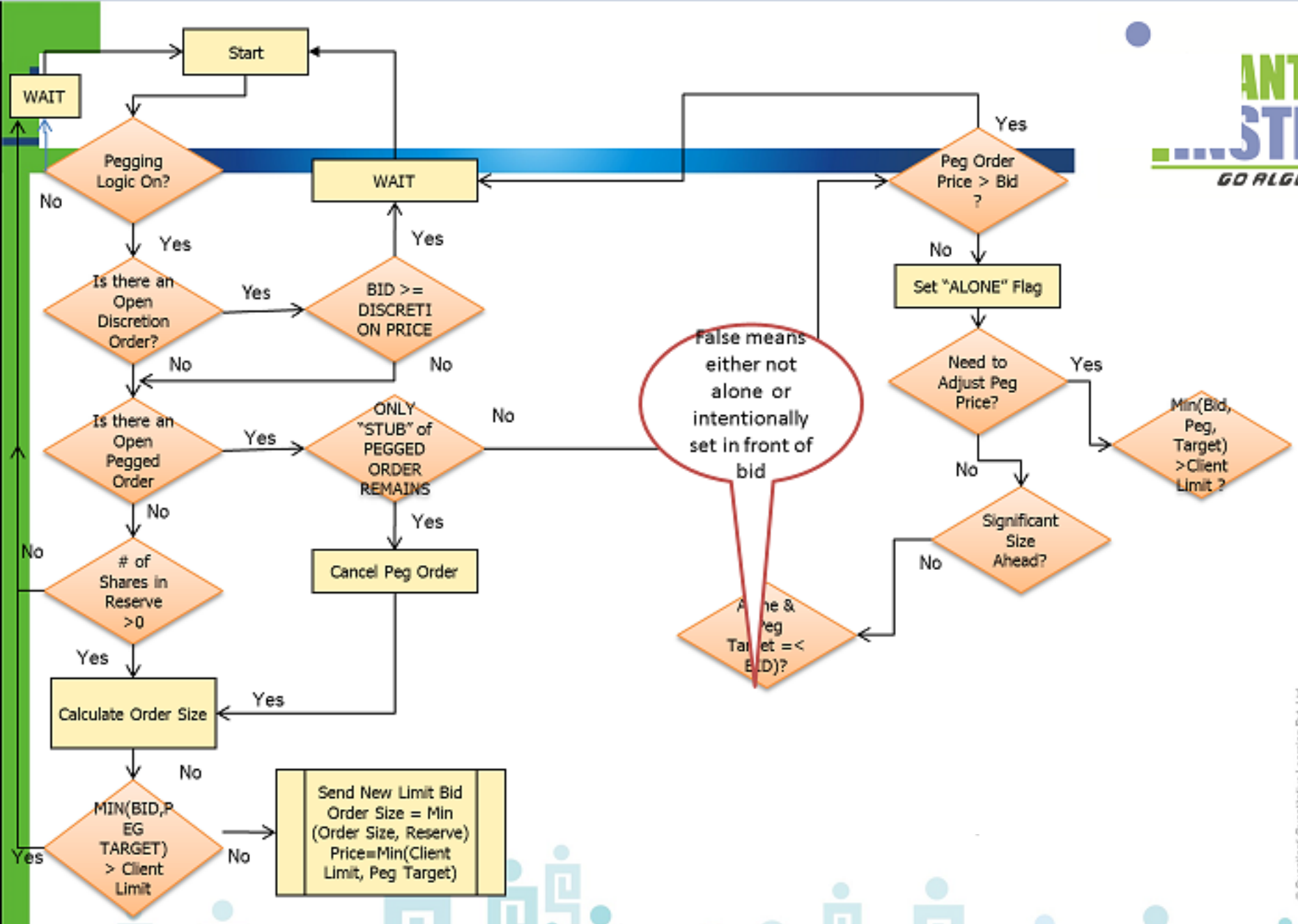


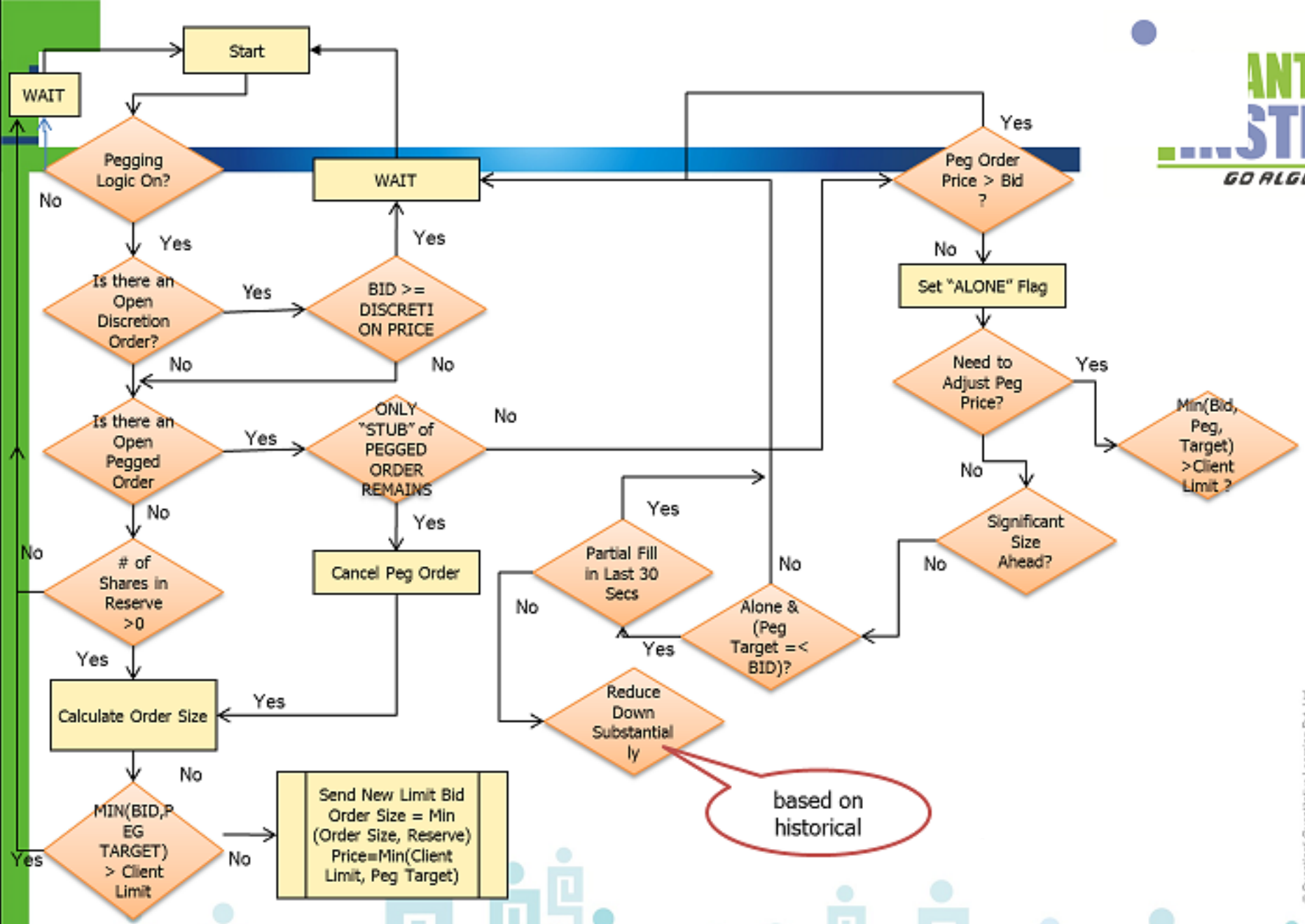


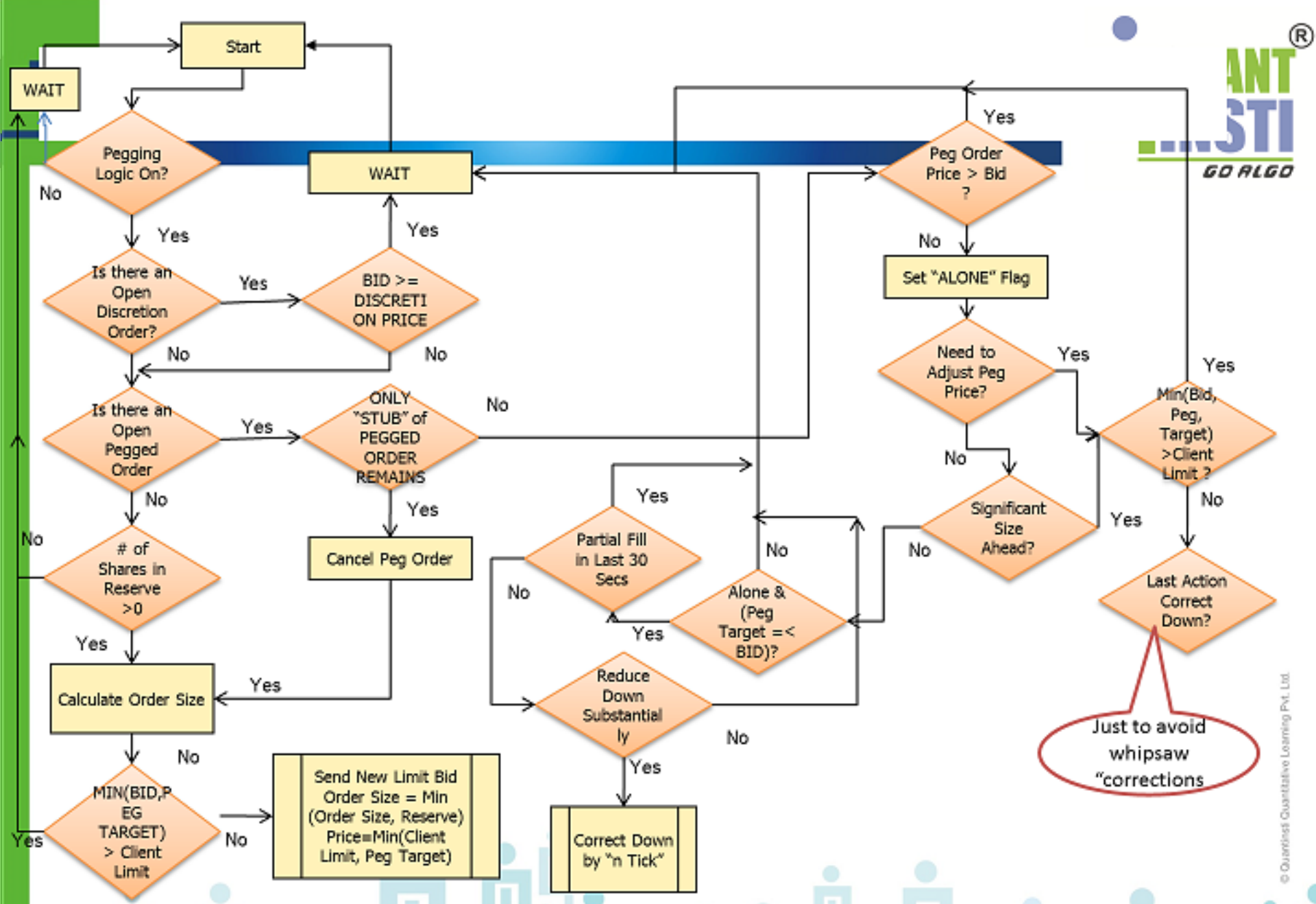


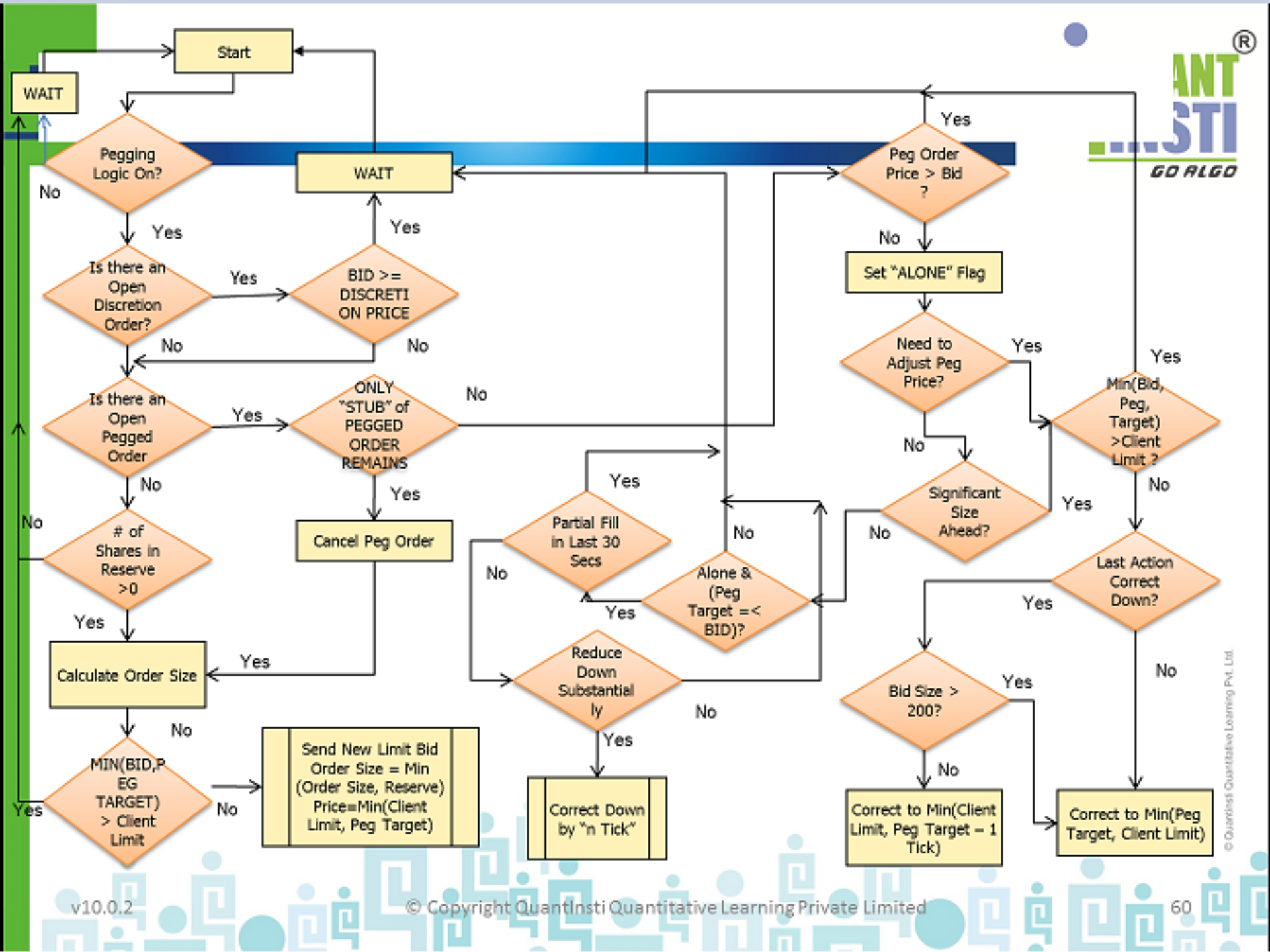


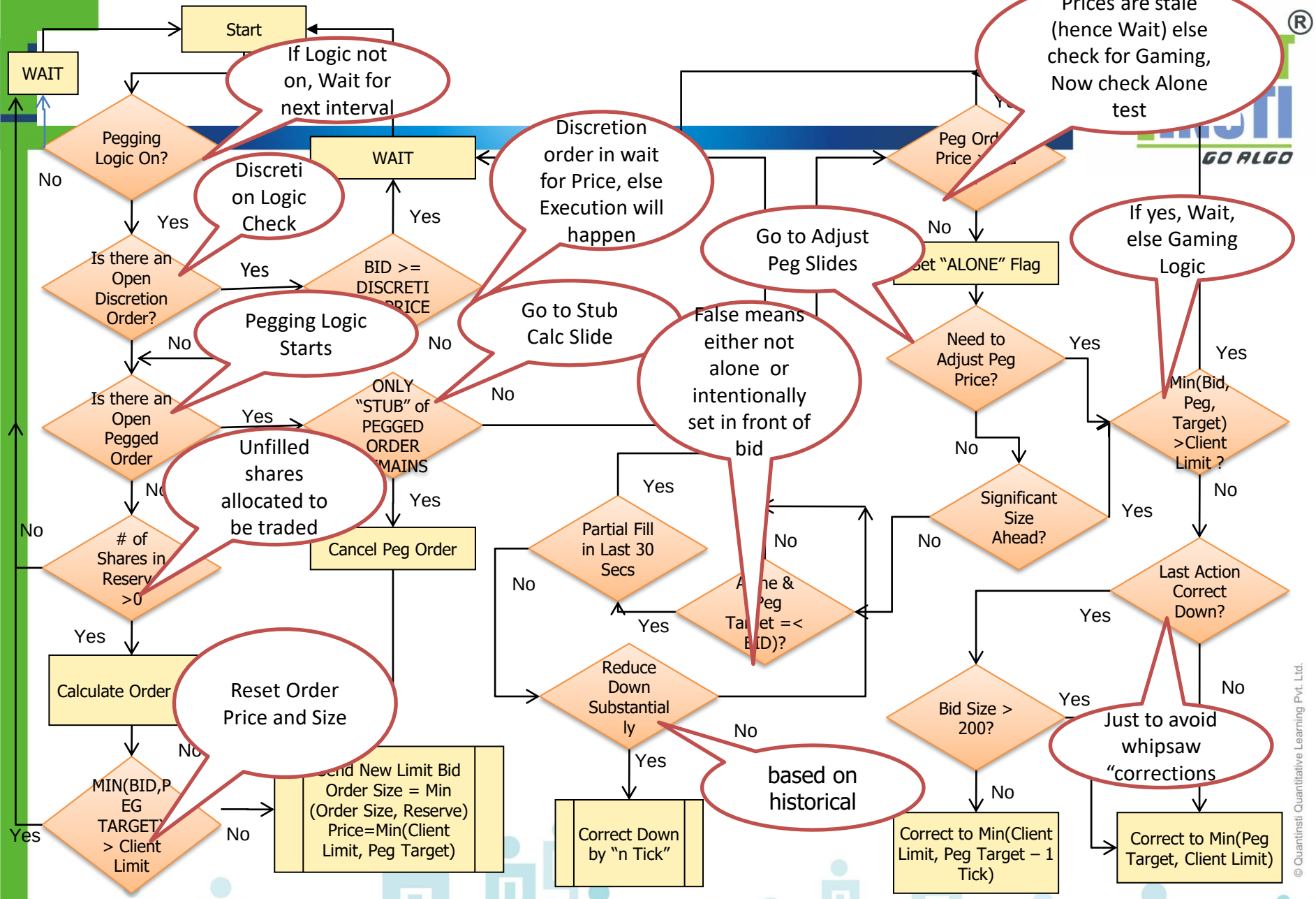






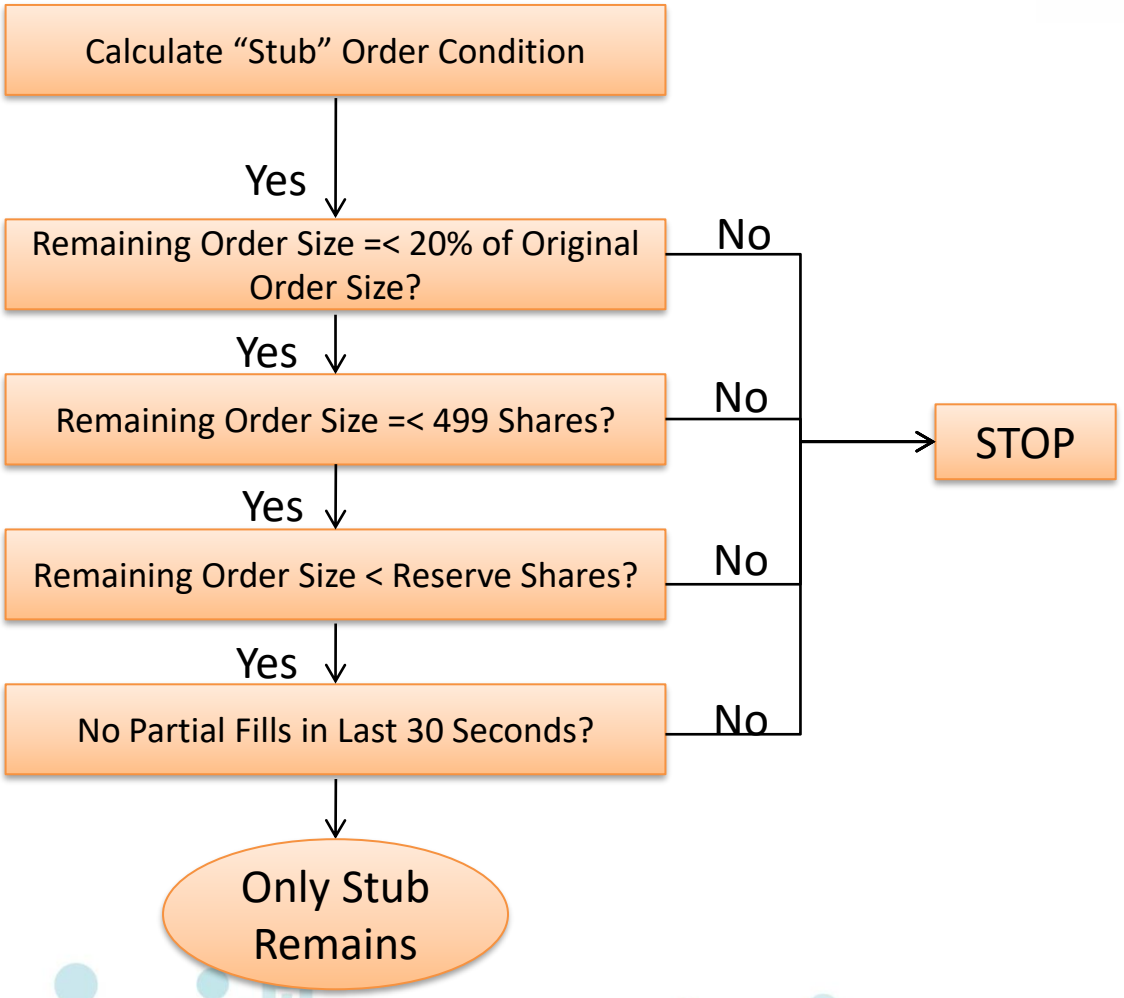




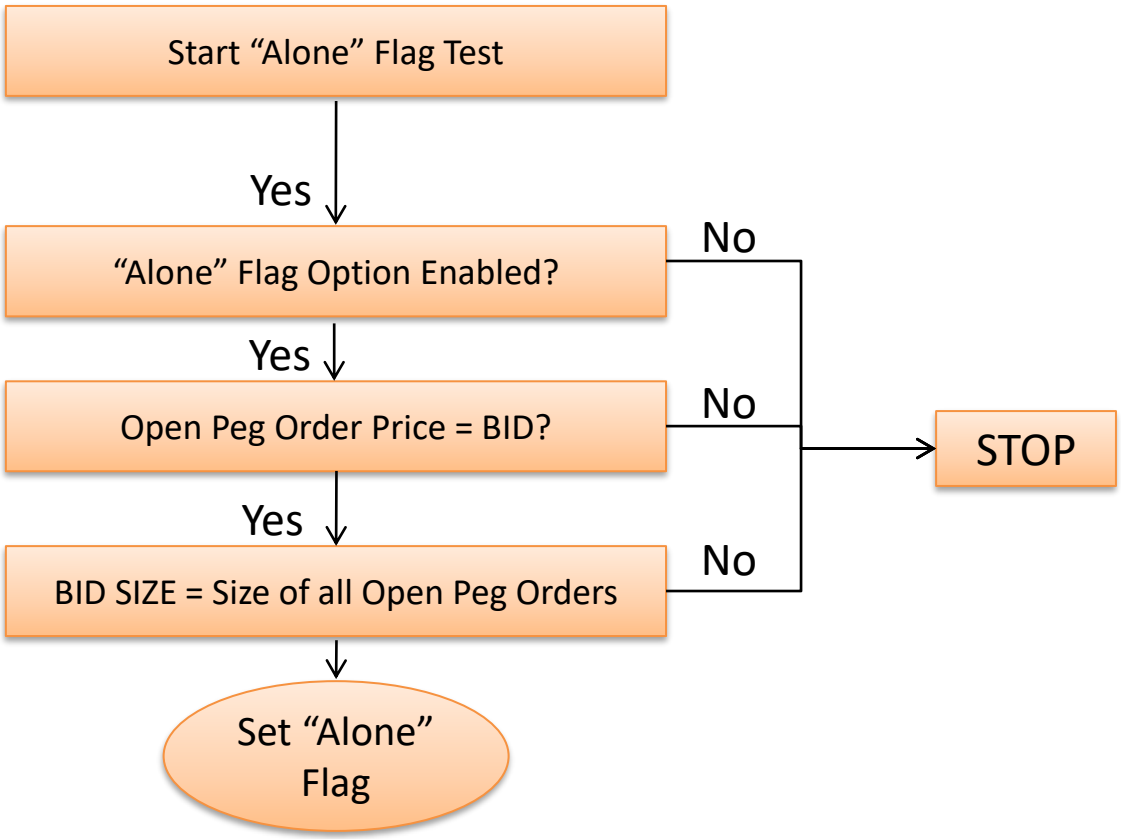


Q & A

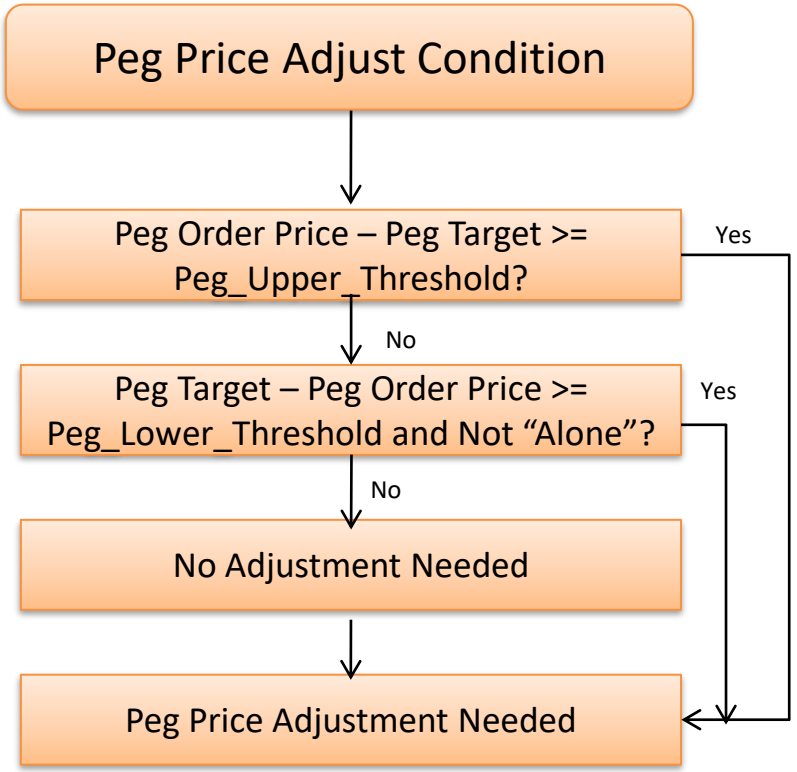
Stub Order Calculation



Start Alone Flag Test

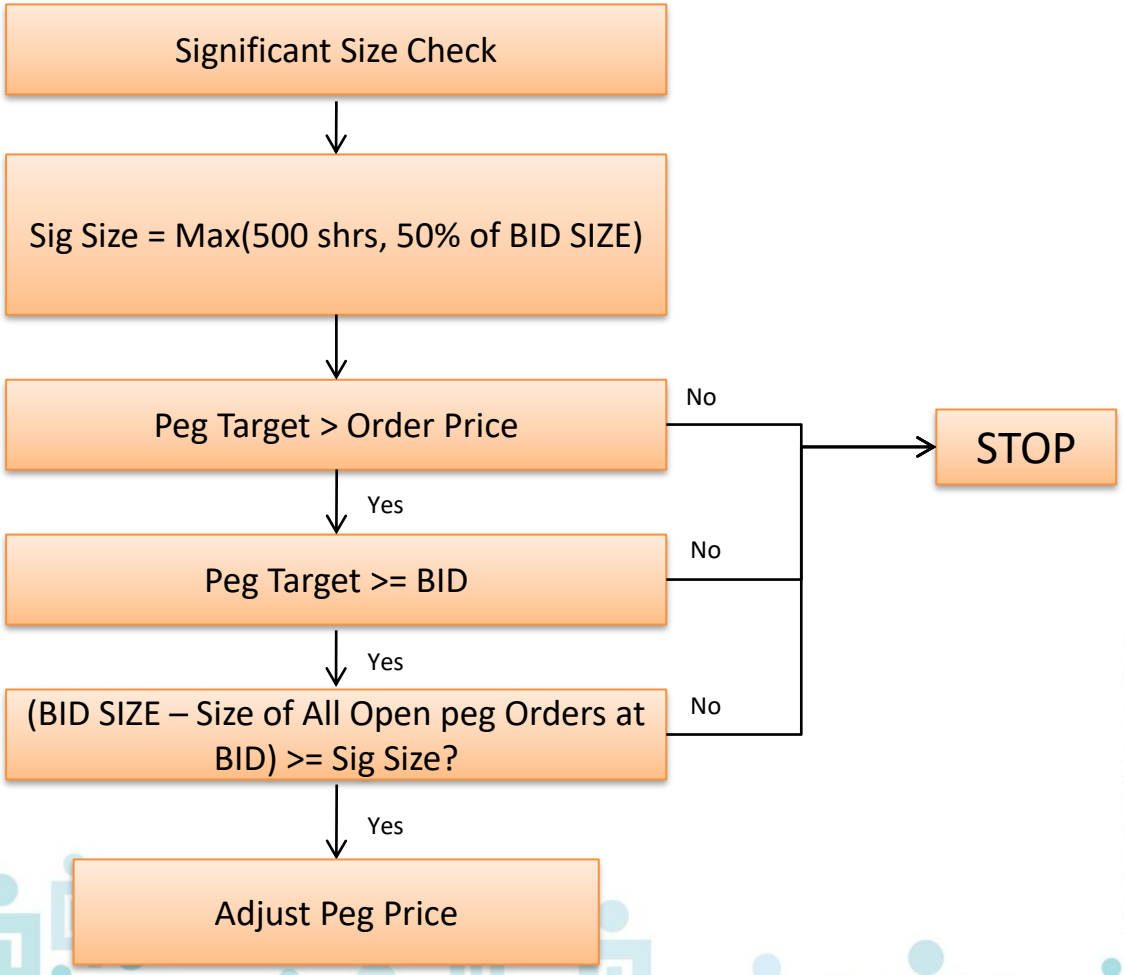


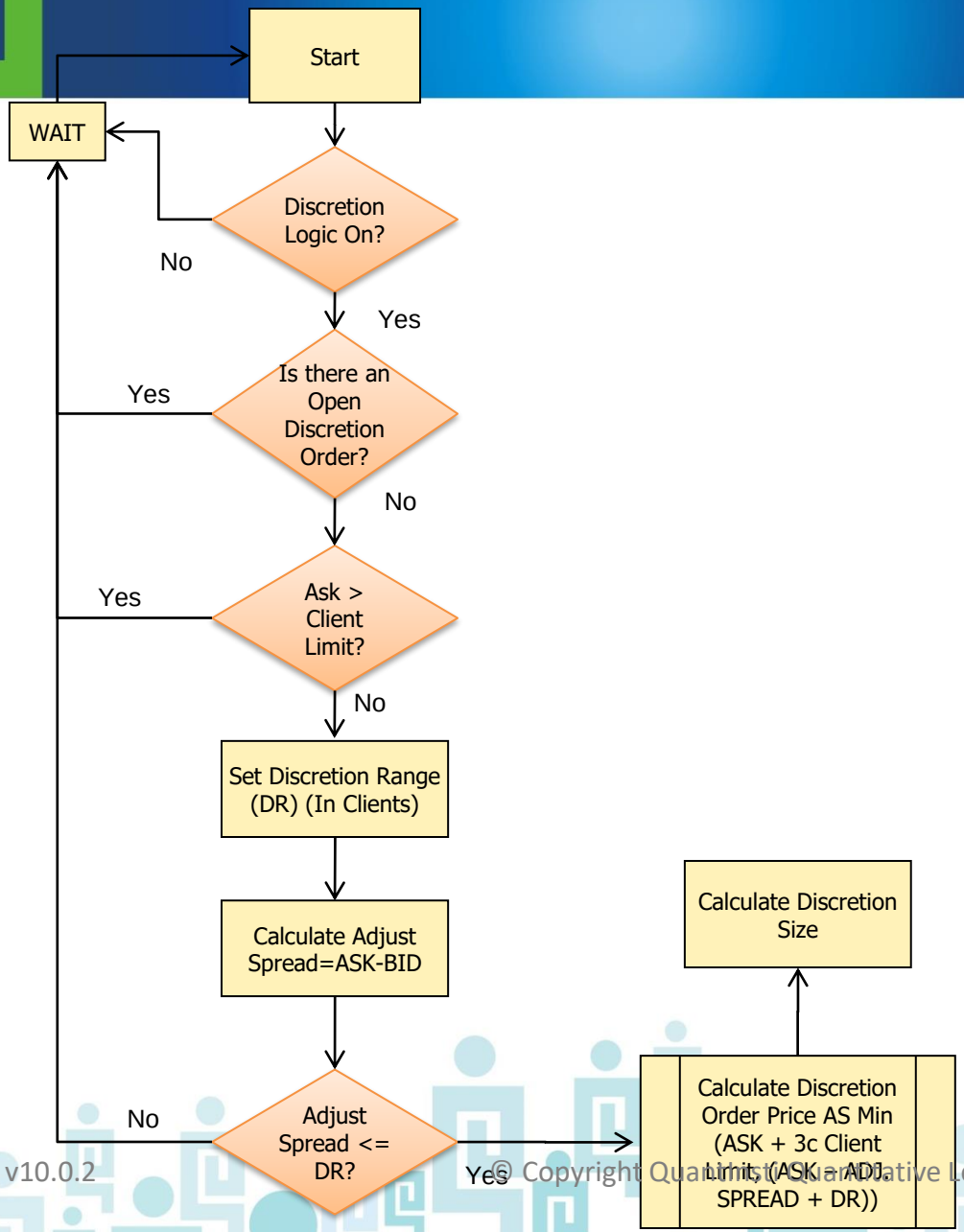
Peg Price Adjust Condition



Significant Size Check

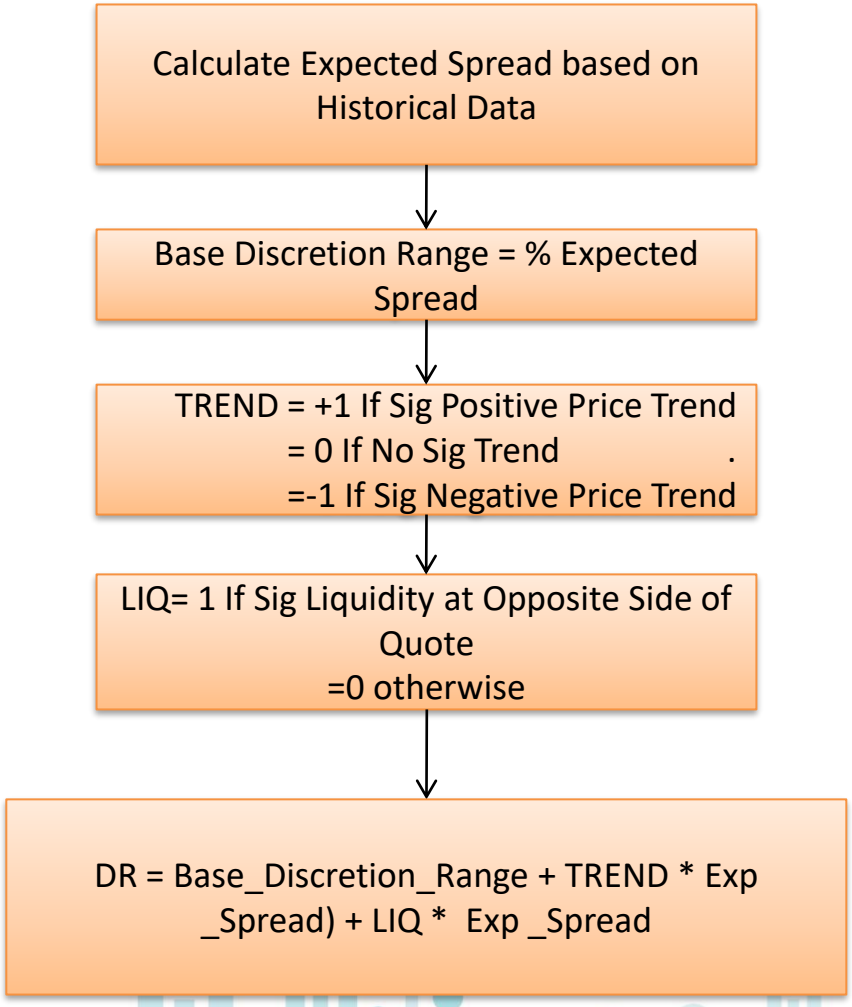
Reason for this check is that the existence of a significant size ahead of peg order will cause the pegged order to be corrected notwithstanding the fact that pegged order is within peg correction threshold amount of the target price





Calculated on the basis of average volumes, typical size, etc.

Set Discretion Range



DR is a function of BDR, ES, Trend, LIQ

Summary of the Strategy

- The peg order agent continuously sends out passive pegged orders attempting to attract market orders,
- While the discretion order agent works in tandem with the peg order agent to send out aggressively priced discretion orders to take advantage of liquidity
- The purpose is to keep the client's trading order on schedule so as to be completed within the specified time horizon

References

- *Trading & Exchanges, Larry Harris*
- *Theory of Financial Risk & Derivative Pricing, JP Bouchaud & Marc Potters*
- *Dark Pools and High Frequency Trading For Dummies, Jay Vaananen*
- *US Patent Application Publication 2004, Bok et al.*
- *Investopedia.com*
- *Wikipedia*

Thank You!

Extra – Stop Orders & Limit Orders

- Difference lies in the purpose of the specified price
- A stop order gets activated when the market price reaches or passes the specified stop price
- A limit order can be executed only at a price equal to or better than the specified limit price