



Algorithmic Trading and Flash Crashes

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Flash Crash – May 6th.

- \$600 billion in market value of US corporate stocks disappeared – down \$900b on the day.
- Causes
 - Fat Finger
 - Stop-loss Triggering
 - Inconsistent Trade Halting Rules
 - Stub Quotes - ultra-low bids
 - NYSE Delay
 - Quote Stuffing - attempt to overwhelm a market

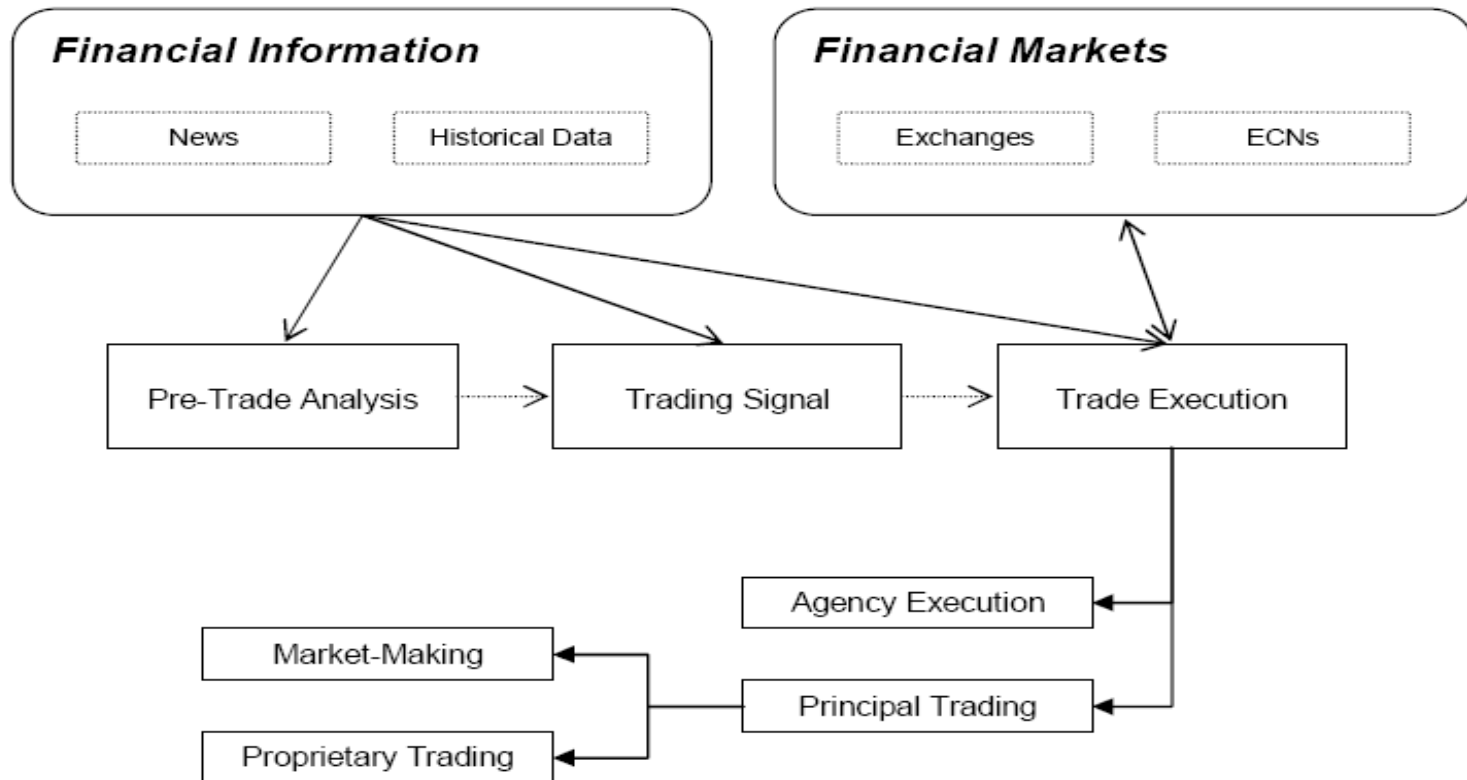


Algorithmic Trading Definition

- **Algorithmic trading is an 'arms race'** - 60%-70% US equity trades by volume now done by algorithms.
- **Algorithmic trading** is the use of computer programs to automate one or more stages of the trading process: pre-trade analysis (data analysis), trading signal generation (what to trade), and trade execution (when and how to trade).
- **High-Frequency trading** is the execution of computerized trading strategies characterized by extremely short position-holding periods.
- Each stage of this trading process can be conducted by:
 - **by humans**
 - **by algorithms + humans** (e.g. low frequency trading)
 - **fully by algorithms** (e.g. high-frequency trading)

Trade Process – what, when, how

- ① **Pre-trade analysis** – analysis properties of asset using of market data or financial news.
- ② **Trading signal** – identifies trading opportunities based on the pre-trade analysis.
- ③ **Trade execution** – executing orders for the selected asset (when and how).



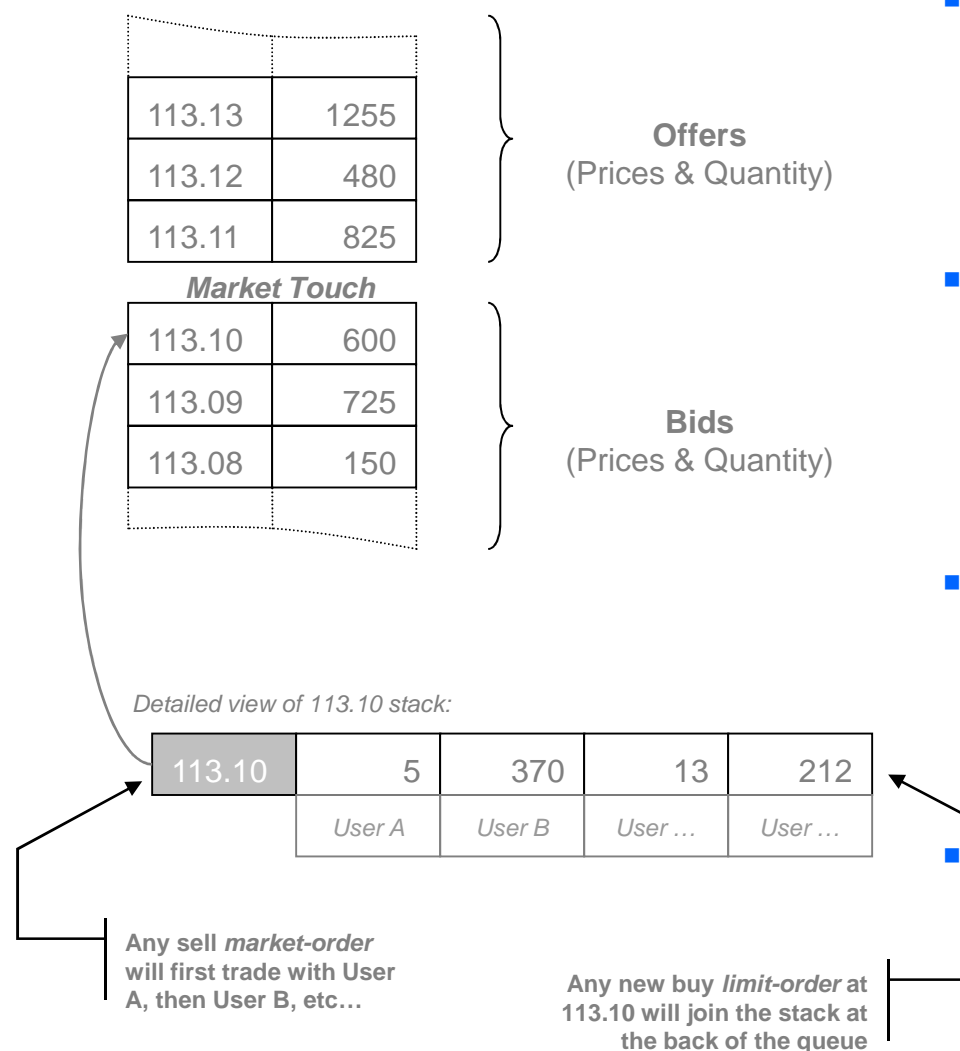
Algorithmic Trading Requirements

- **Centralise Order Book** – shared centralized order book that lists the buy and sell orders for a specific security ranked by price and order arrival time
- **Markets** – deployed for highly liquid markets and (typically) high-frequency trading (equities, futures, derivatives, bonds, FX)
- **Systems** – AT systems have three broad sources:
 - **In-house systems** - to support their proprietary trading and market-making.
 - **Client systems** - systems for banks' clients to use.
 - **Vendor systems** - off-the-shelf and bespoke AT system.
- **Information Exchange** – central to the operation of these systems are financial protocols (so-called Financial Information eXchange FIX Protocol)

Centralised Order Book

Last Trade				9.79	Volume 1925332			
Total	Ord	Size	Bid	Ask	Size	Ord	Total	
1277	3	1277	9.79	9.80	1365	2	1365	
6083	6	4806	9.78	9.81	8863	3	10228	
6283	1	200	9.77	9.82	7550	6	17778	
20231	4	13948	9.76	9.83	7615	5	25393	
33962	12	13731	9.75	9.84	3682	3	29075	
52779	4	18817	9.74	9.85	9079	4	38154	
53094	2	315	9.73	9.86	2260	2	40414	
53894	1	800	9.72	9.87	5000	1	45414	
60085	1	6191	9.71	9.88	2500	1	47914	
71371	14	11286	9.70	9.89	6100	3	54014	

Orders, stacks & matching



- **Order types:**
 - market order (immediately)
 - limit order (specific price)
 - iceberg order (large single order that has been divided into smaller lots)

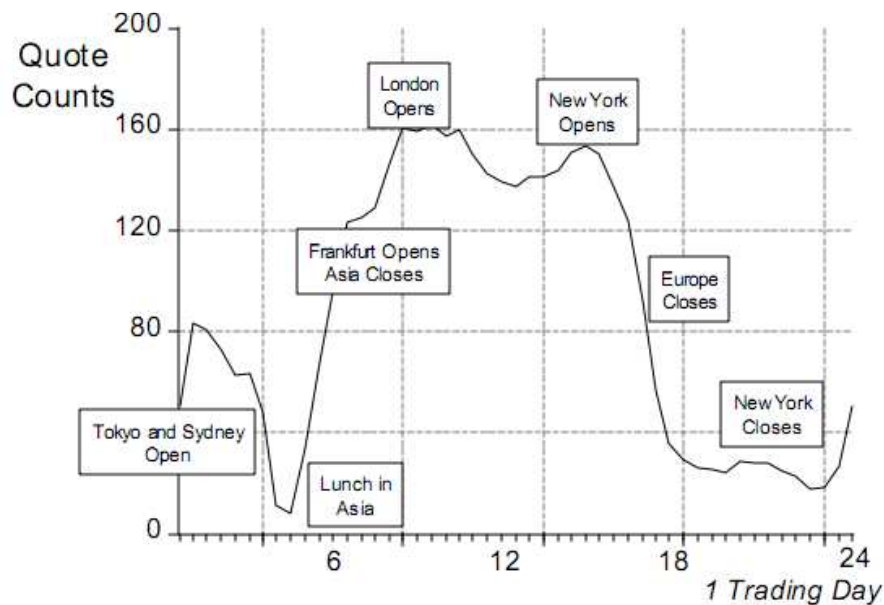
- **Time in force:**
 - day order (valid only for less than a day)
 - good-till-cancelled (valid until executed or cancelled)
 - fill-or-kill (immediately execute or cancel)

- **Conditional orders:**
 - stop order (to sell (buy) when the price of a security falls (rises) to a designated level)
 - stop limit order (executed at the exact price or better)

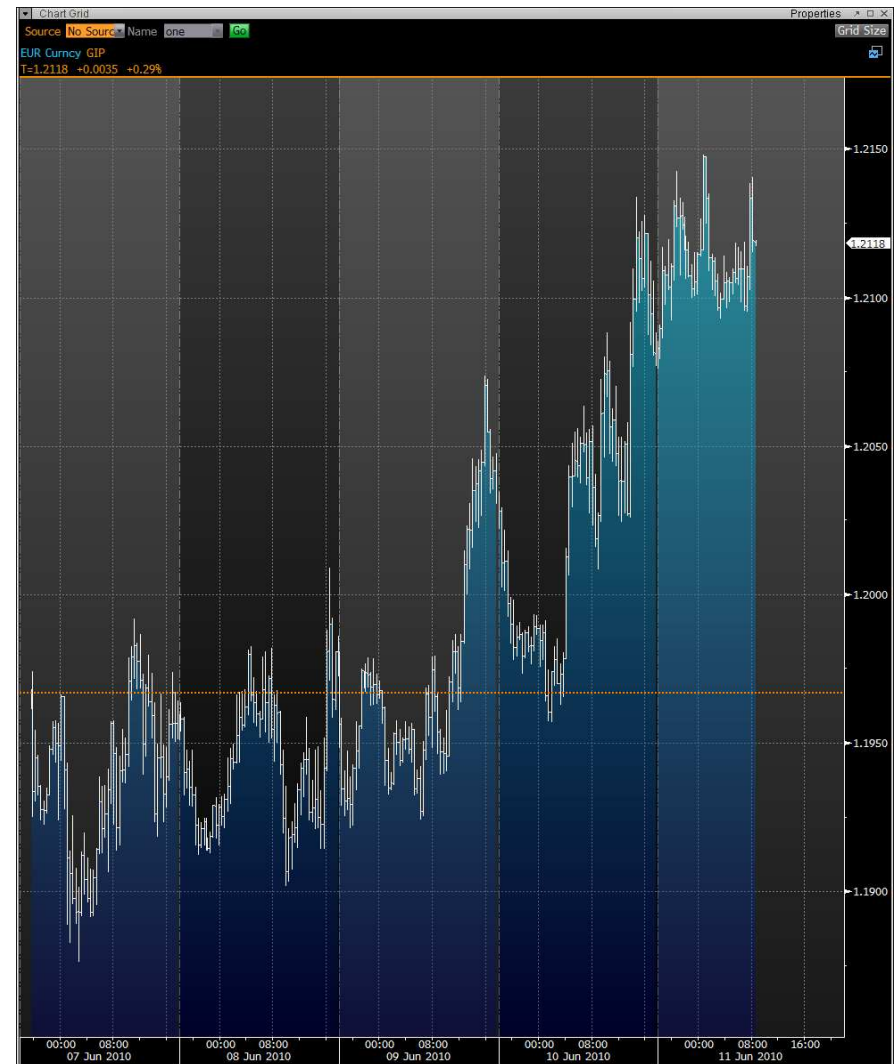
- **Discretionary order** (broker decides when and price)

Market Microstructure

- The graph shows the intra-day price of EUR/USD.
- EUR/USD is a very liquid currency with tight spreads.
- Difficult to predict as is very heavily traded, often the driver for other currency pair movements.



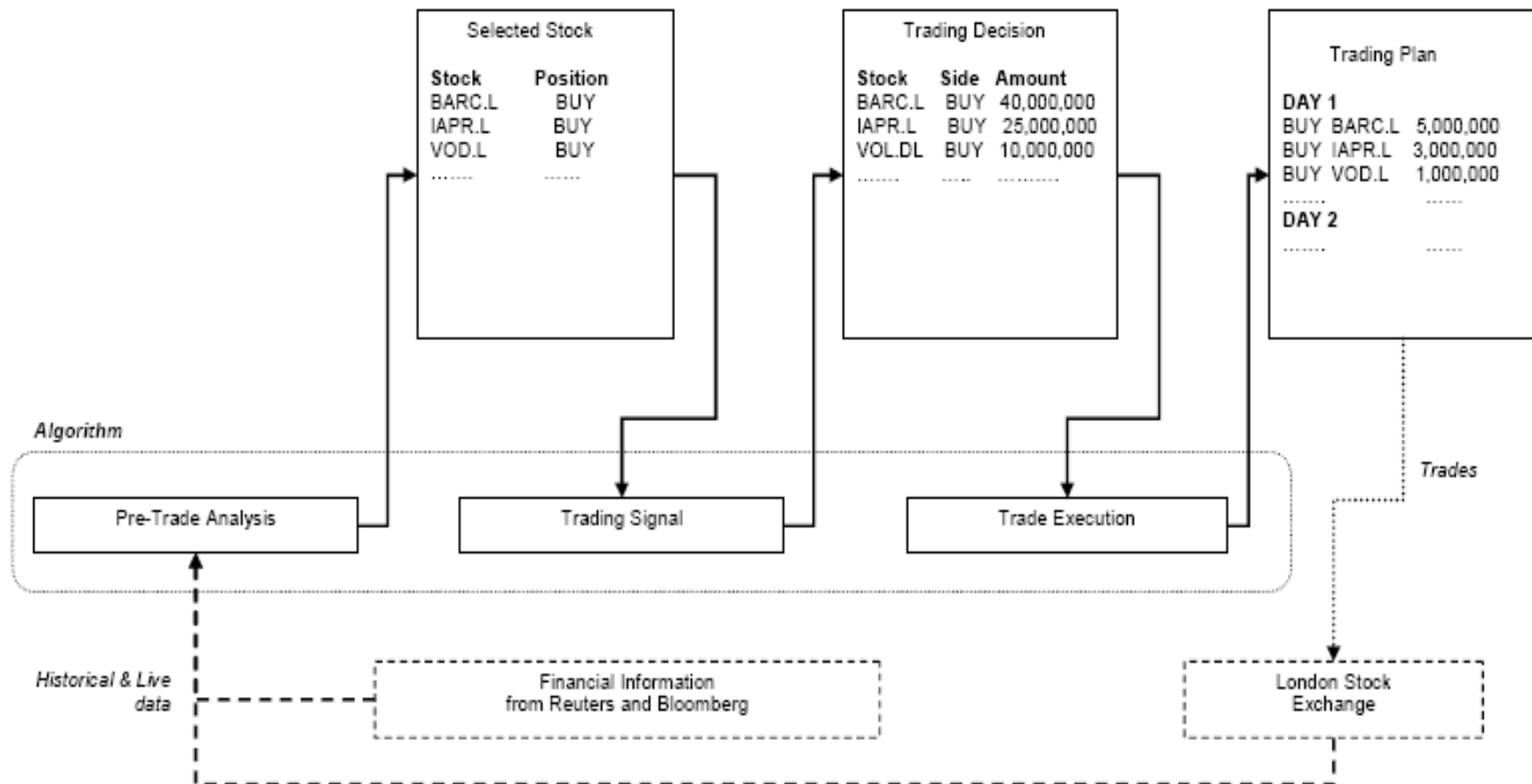
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Trading Types & Objectives

- **Agency/Brokers trading** - trading on behalf of clients (by buying or selling stocks or bonds)
 - **Broker AT systems** - seek to minimize the cost of trading by minimize market impact cost
 - **Principal/Proprietary trading** - traders actively trade stocks, bonds, options, commodities, derivatives or other financial instruments using institution's own money
 - **Proprietary AT systems** - seek to maximize profits against some measure of risk
- * In practice all algorithms target profits – either cost savings or profit & loss

Algorithmic Trading Equities example system



Pre-trade analysis cont.

Pre-trade analysis in an algorithmic trading system generally involves the analysis of financial data or news with the aim to forecast future price movement or volatility as well as the generation of trading signals when a trading opportunity occurs.

- **Fundamental Analysis** - detailed analysis of related information that may affect asset prices.
- **Technical Analysis** - predicting future price movements based only on observing the past history of asset prices.
- **Quantitative Analysis** - predicting future price movements based only on observing the past history of asset prices.

Trade Signal Generation

- the analysis of changing market information to detect the trading opportunities within the market.
- this level of automation is generally applicable to all but high-frequency trading, where complete automation is a prerequisite.
- level of automation is often employed by systematic asset managers and trading institution.
- the reason for a manual execution can be that the trader requires further discretionary input or the trade is not executable electronically due to the order size versus the market liquidity.

Trade Signal cont.

The signal generation usually involves the analysis of changing market information to detect the trading opportunities within the market, and the result is a trading signal indicating when to buy and when to sell a particular financial instrument.

- **Prediction Process** - responsible for modeling the whole portfolio as part of a very noisy dynamic process and for predicting its time-dependant evolution.
- **Control Process** - involves transforming the predictions obtained by the modeling/ prediction component into trading signals.

Trade Execution

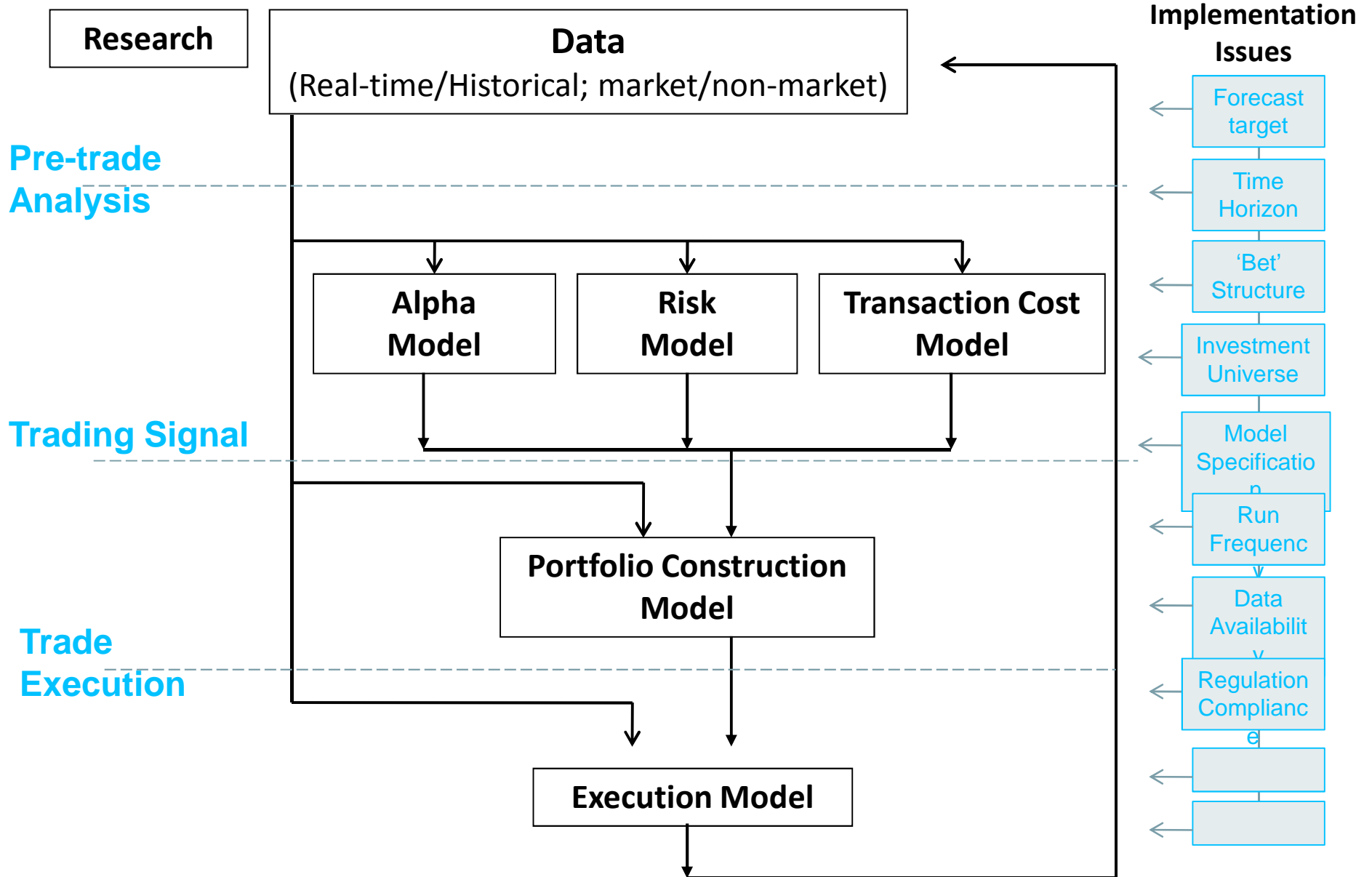
- involves sending buy or sell order to a market to be filled, by a broker firm via an online broker account or directly to the exchanges.
- If the trading decision is generated algorithmically, the trade is typically proprietary.
- actual trading decision can be made by a human, and the algorithm only optimizes the execution: this is often associated with agency/broker trading.

Trade Execution cont.

To execute a trade, an order has to be submitted to a trading venue, where the choice depends on several factors including order size, trading mechanism, and degree of trader's anonymity.

- **Choice of trading venue** – market(s) in which the order is to be submitted; influenced by liquidity, trading mechanism and degree of trader's anonymity.
- **Choice of trading schedule** - break order into several smaller orders with aim to minimize impact of trade on price.
- **Choice of order type** - market order gives immediate execution but the execution price is not certain; limit order guarantees the execution price, but partial execution.

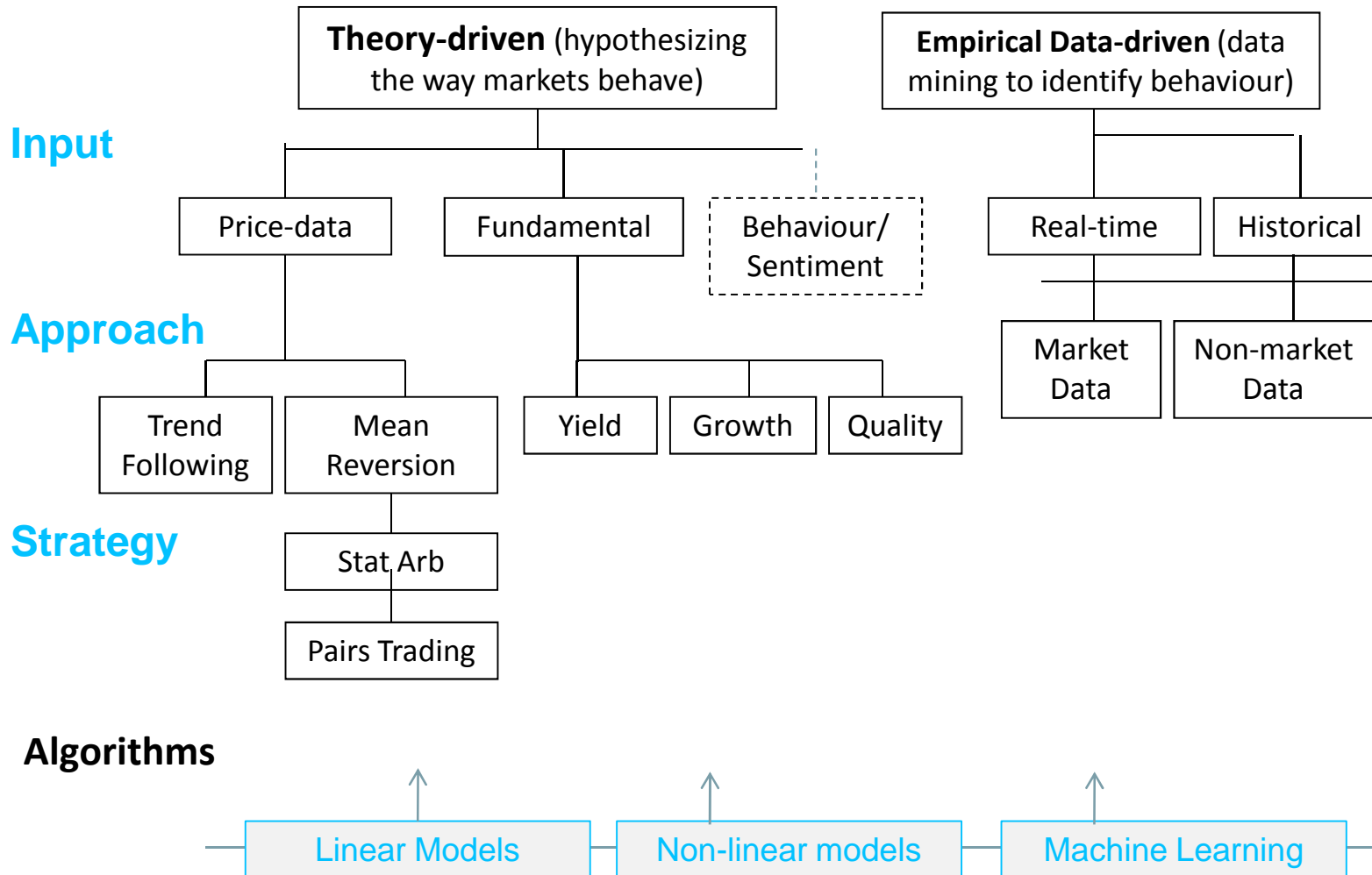
Algorithmic (automated/systematic) trading strategies



Alpha Trading Model

(predicting the future of instruments)

Quant Style

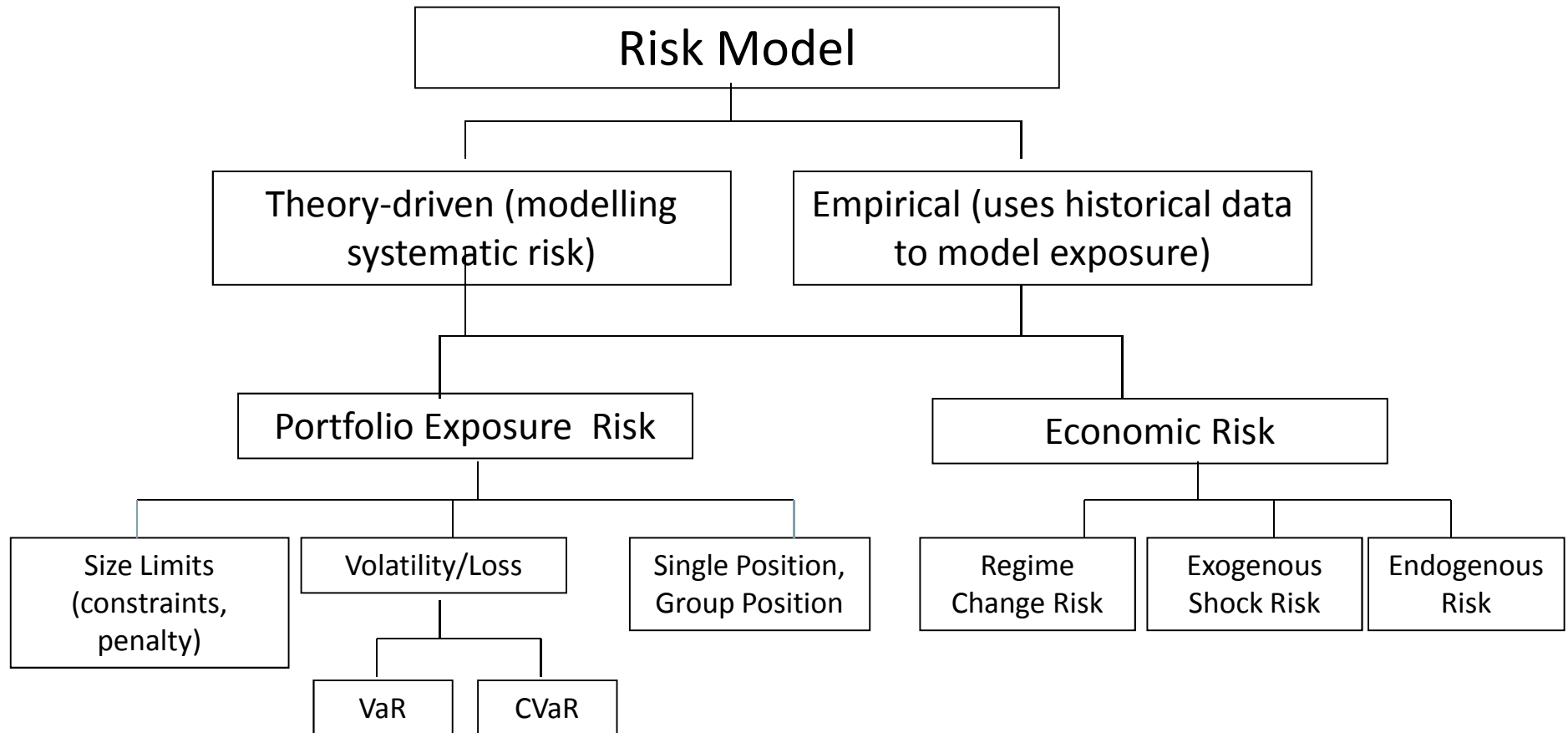


HFT - Strategies

- Latency Arbitrage
 - Observing market moves and dealing on prices before market makers have a chance to update pricing
- Momentum Trading
 - Using the acceleration of price moves to determine the entry and exit points of trend driven trades
- Correlation Trading
 - Trading generated by correlated price moves between currency pairs or other liquid markets
- Mean Reversion
 - Attempt to capture value from range bound market moves
- Data Response
 - Systematic response to economic data releases
- Market Knowledge
 - Use of knowledge of flows/players in the market to dictate positioning
- Cash Futures
 - Capturing the value of arbitrage opportunities between spot and futures markets
- Imbalance
 - Trade decisions are based on relative amounts on the bid and offer
- Queue Priority
 - Utilizing the structure of an market's order book optimize order placement within a market

Risk Model

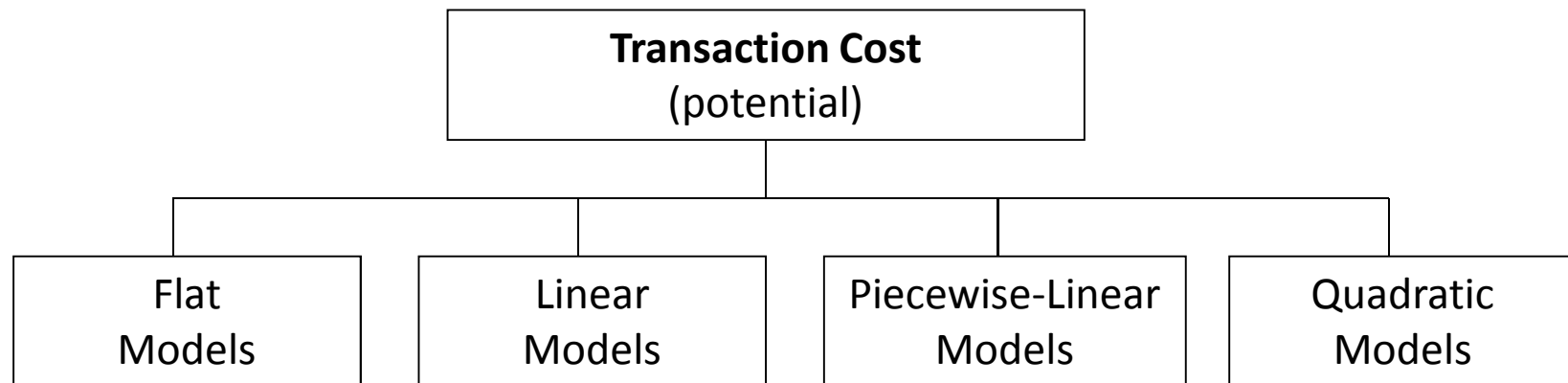
eliminating or reducing exposure



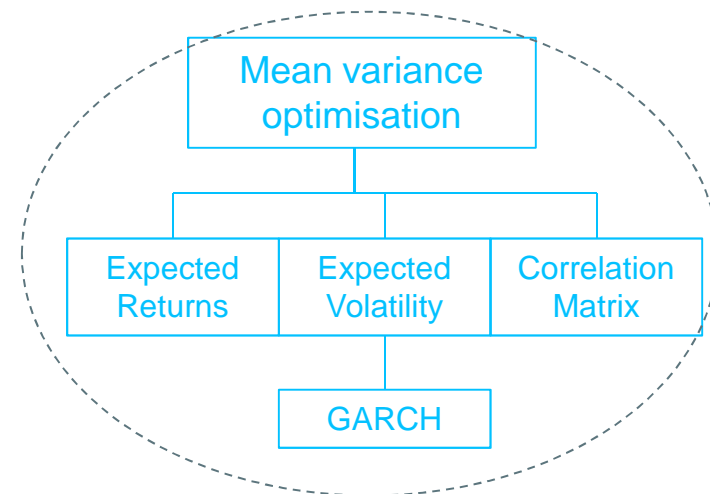
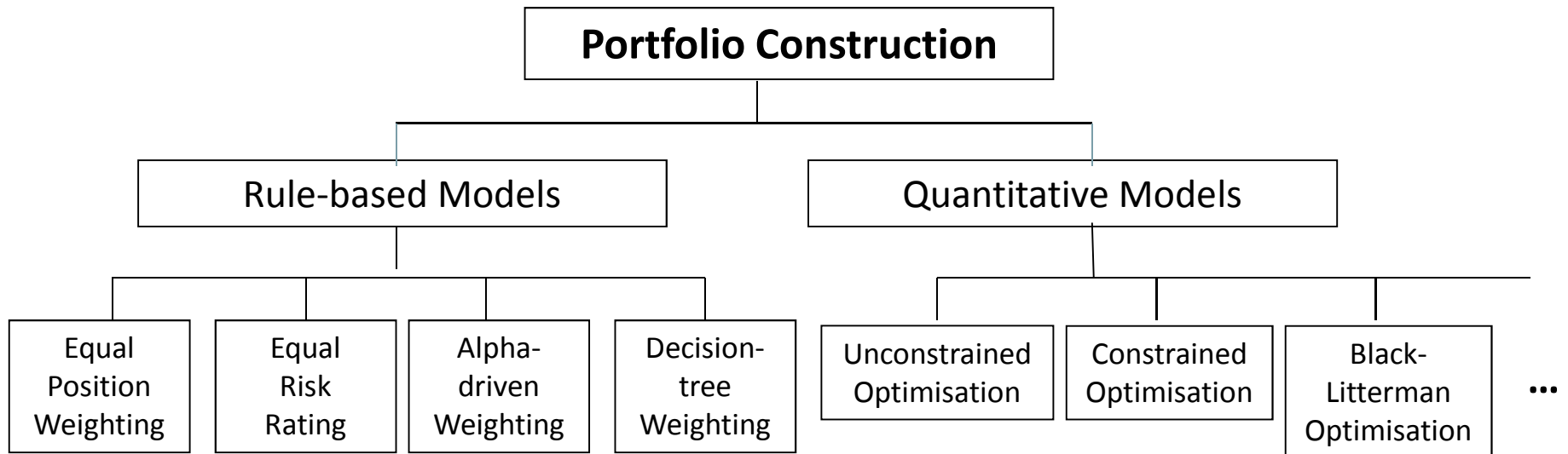
Transaction Cost Model

advising the Portfolio model on potential costs of transactions

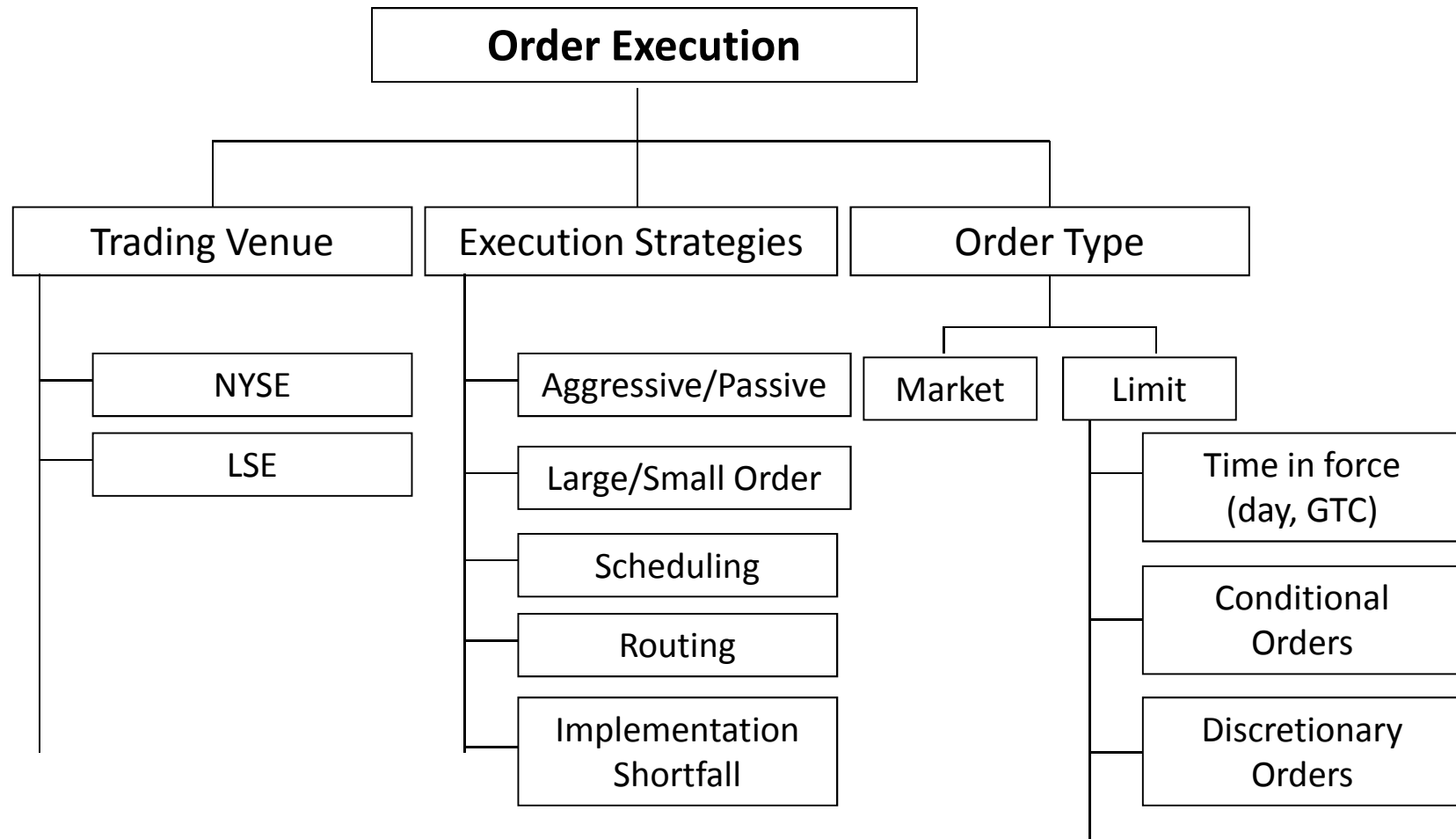
- **Commissions** (Fees, Clearing, Settlement)
- **Slippage** (change in price between decision and execution)
- **Market Impact** (order size, liquidity)



Portfolio Construction Model



Execution Model



Algorithmic Trading Strategies

■ Pre-Trade Analysis

Pre-trade focuses on investment strategy-related algorithms:

- **Arbitrage** – the practice of taking advantage of a price differential between two or more markets.
- **Auto-Hedging** – aims to aggregate risk in the portfolio.
- **Market Making** – buying at below market price or offering to sell above market price.
- **Benchmarking** – used by traders to mimic an index's return.
- **Gaming** – aims to exploit other algo traders.

■ Trade Execution

For Trade execution we group the algorithm strategies:

- **Scheduling algorithms** – the strategy for placing the orders
- **Routing algorithms** – how the orders are broken up for placement
- **Implementation shortfall algorithms** – how the transaction costs of executing the order are improved.

Trade Execution Scheduling Algorithms

- **Volume Weighted Average Price (VWAP)** – it executes a buy order in a financial instrument (e.g. stock) as close as possible to its historical trading volume in an effort to reduce the trade's impact on the market.
- **Time Weighted Average Price (TWAP)** - it trades based on the clock, allowing traders to slice a trade up over time, and is most appealing for those investing in a small, illiquid stock where volume analysis makes little sense.
- **Target/Trade Volume (TVOL)** – it executes the trade based on completion time of the order and price based on market “ticks” or volume.
- **Market Call (MC)** - implements a market trade, ranging from passive to aggressive, over a flexible execution time frame.

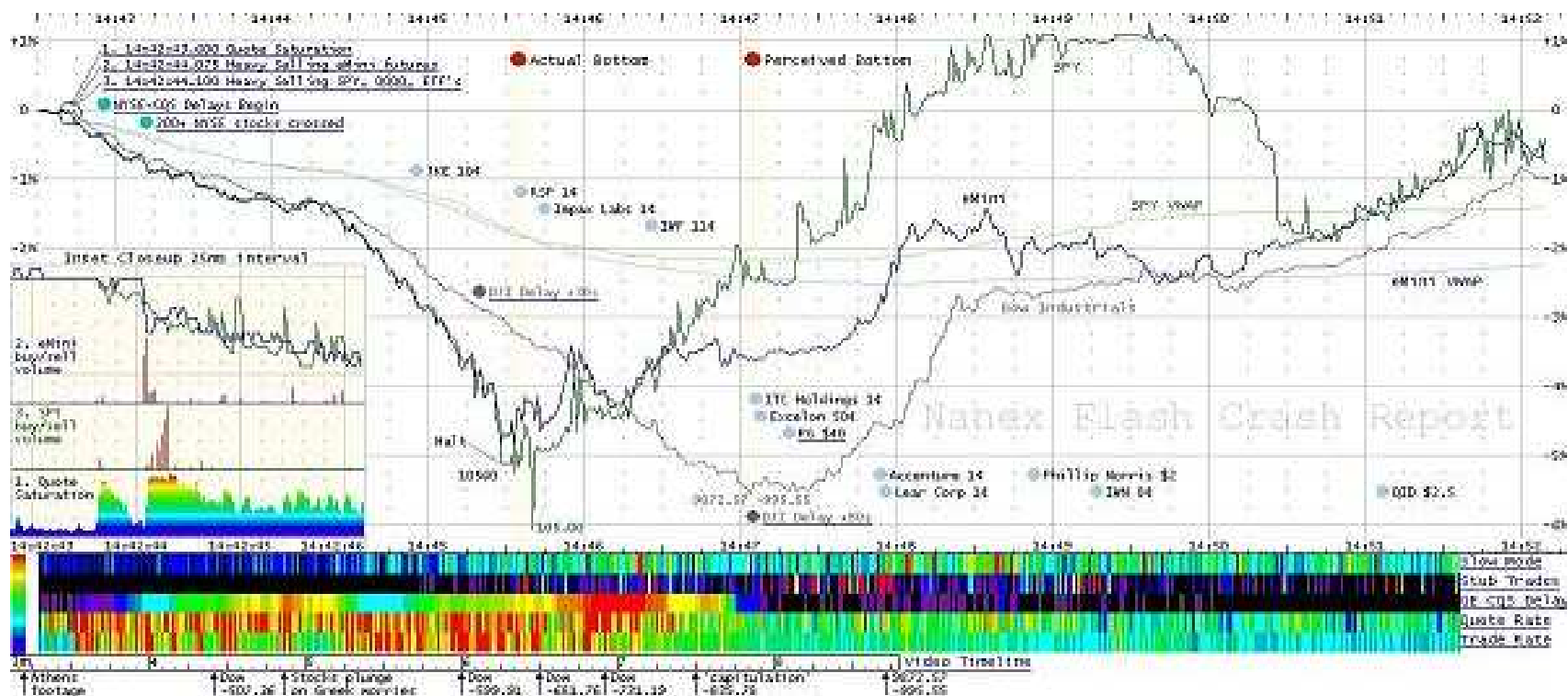
Trade Execution Routing Algorithms

- **Order Splitting/Slicing** – with the classic ‘order splitter’ slicing is done based on price, quantity and time.
- **Optimized Basket/List Trading** – these are orders that are grouped together and executed as a unit.
- **Smart Order Routing** – with such algorithms, liquidity from many different sources is aggregated and orders are sent out to the destination offering the best price or liquidity while minimizing market impact.

Trade execution order types

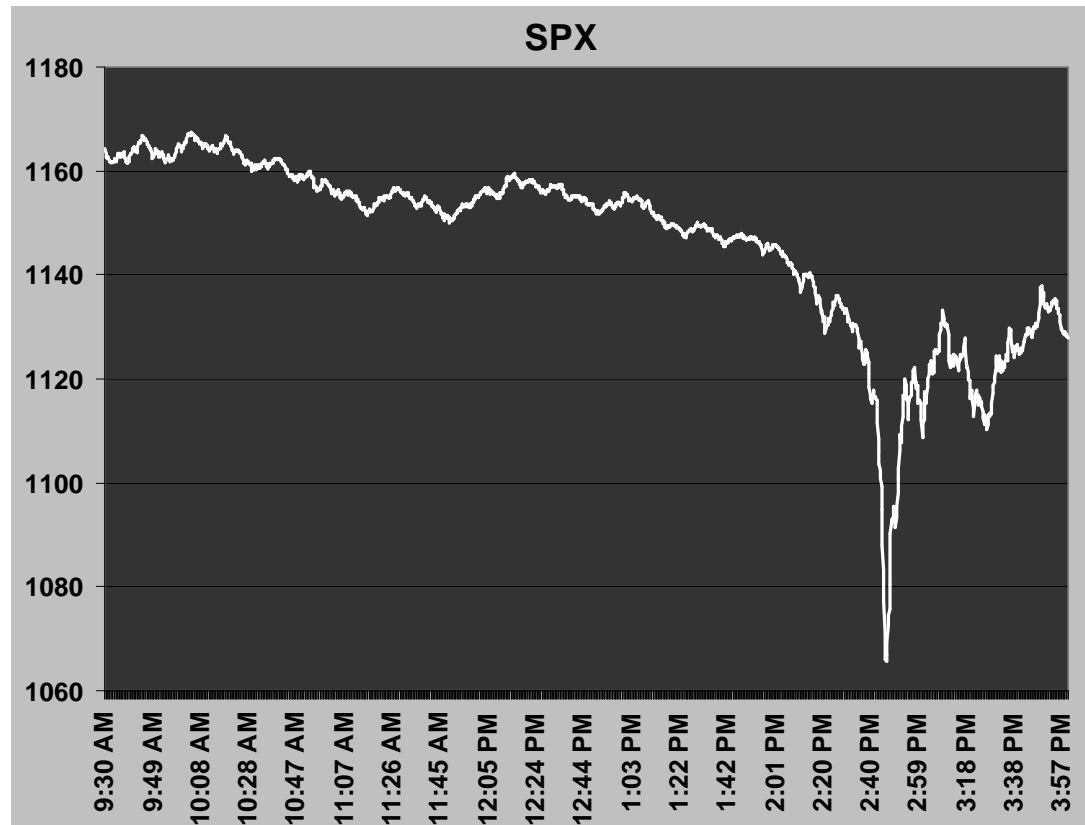
- **Market order** - is a buy or sell order to be executed by the broker immediately at current *market* prices.
- **Limit order** - is an order to buy a security at no more (or sell at no less) than a specific price.
- **Iceberg order** – is where a large single order that has been divided into smaller lots, usually by the use of an automated program, for the purpose of hiding the actual order quantity.
- **Day order** (the most common)- is good only for one day. It is in force from when it is entered to the end of regular trading on the same day.
- **Good-till-cancelled** order requires a specific cancelling order. It can persist indefinitely (although brokers may set some limit, for example, 90 days). This is good for when the investor wishes to sit on the beach for a few weeks.
- **Conditional orders** – is a conditional order is any order other than a limit order that requires the broker to check whether a specific condition has been met.
- **Stop order** (also *stop loss order*) - is an order to buy (or sell) a security once the price of the security has climbed above (or dropped below) a specified stop price.
- **Discretionary order** - is an order that allows the broker to delay the execution at their discretion to try to get a better price.

Flash Crash



charts of quote-stuffing — a high-frequency strategy that involves firing a massive number of quotes at a market and then quickly cancelling them

Flash Crash – May 6, 2010



\$600 billion in market value of US corporate stocks disappeared

Flash Crash Causes

- Fat Finger in single-stock / index future
- Stop-loss Triggering
 - If the market price falls through the stop loss trigger price, then the order will be activated and the long position will be automatically closed out.
- Inconsistent Trade Halting Rules
- Stub Quotes
 - ultra-low bids that are placed when reserve size is depleted
- NYSE Delay
- Quote Stuffing
 - attempt to overwhelm a market with excessive numbers of quotes by traders. This involves placing and then almost immediately cancelling large numbers of rapid-fire orders to buy or sell stocks

- SEC Report <http://www.sec.gov/news/studies/2010/marketevents-report.pdf>

Proposed Regulatory Changes

- Circuit breakers based on the Dow Jones Industrial Average instituted for the market following '87 Crash
- Must quote within 30% of best price
- “Trading Pauses” for *single stocks* that drop 10% in 5 minute period
 - Applies to all exchanges and derivatives

Dark Pools

Dark Pools are a type of trading platform that allows large blocks of shares to be traded without the prices being revealed publicly (to other traders) until after trades are completed.

Dark Pools

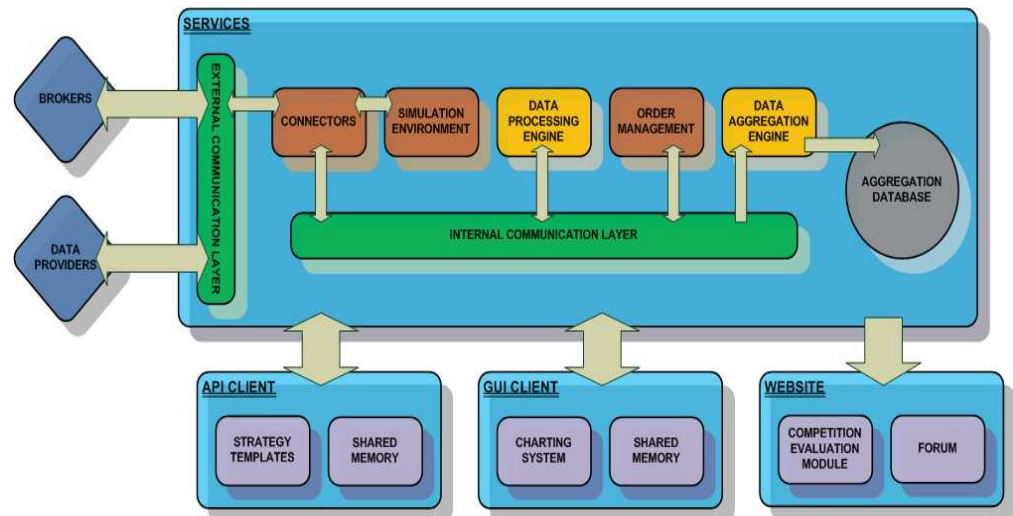
- **Dark pools:** are crossing networks that provide liquidity that is not displayed on order books. This is useful for traders who wish to move large numbers of shares without revealing themselves to the open market.
 - Dark liquidity pools offer institutional investors many of the efficiencies associated with trading on the exchanges' public limit order books but without showing their hands to others. Dark liquidity pools avoid this risk because neither the price nor the identity of the trading company is displayed.
- **Gaming:** Manipulating the price of a stock to increase profits at the expense of the investor on the other side of the order in a dark pool. Common anti-gaming features offered by dark pools include setting minimum order sizes and prequalifying participants that meet a certain profile.
- **Ping:** The most common way to glean information about an order in a dark pool. Often considered a type of gaming, an investor submits a small order to a dark pool to gauge liquidity. After determining there is liquidity, the pinger will drive the price of the stock up or down on the public exchange by buying or selling a few shares in the market. The pinger will then return to the pool to execute at the manipulated price.

UCL's ATRADE

Algorithmic Trading & Risk Analytics Development Environment

Platform Capabilities

- ❑ **Simulation & Real Trading** – the platform allows users to trade virtually or with real money.
- ❑ **Rapid Prototyping** – the platform is a framework for developing, trading, testing and evaluating the ‘algorithm’ risk.
- ❑ **Data Processing & Aggregation** – it’s capable of aggregating and processing data in real-time.
- ❑ **R & Matlab** – incorporation of statistical/mathematical computing environments.
- ❑ **Black Box Models** – the platform evaluates risk of black box models, without a need of handing the source of the model to anyone.
- ❑ **Multiple Models** –the platform supports automated evaluation of multiple models concurrently, and generates statistical performance reports.
- ❑ **Secure Remote Access** – it provides an API that allows remote access to major functionalities of the platform.



Conclusions *Algorithmic Trading future trends*

- **High Frequency Trading** - also known as HFT, refers to the buying and selling of stocks at extremely fast speeds with the help of powerful computers.
- **Dark Pools** - are a type of trading platform that allows large blocks of shares to be traded without the prices being revealed publicly (to other traders) until after trades are completed.
- **Exchange Traded Funds** - an ETF is an investment vehicle traded on stock exchanges, that combines the valuation feature of a mutual fund or unit investment trust, which can be bought or sold at the end of each trading day for its net asset value, with the tradability feature of a closed-end fund, which trades throughout the trading day at prices that may be more or less than its net asset value.