Tackling the Challenges of Market Simulation

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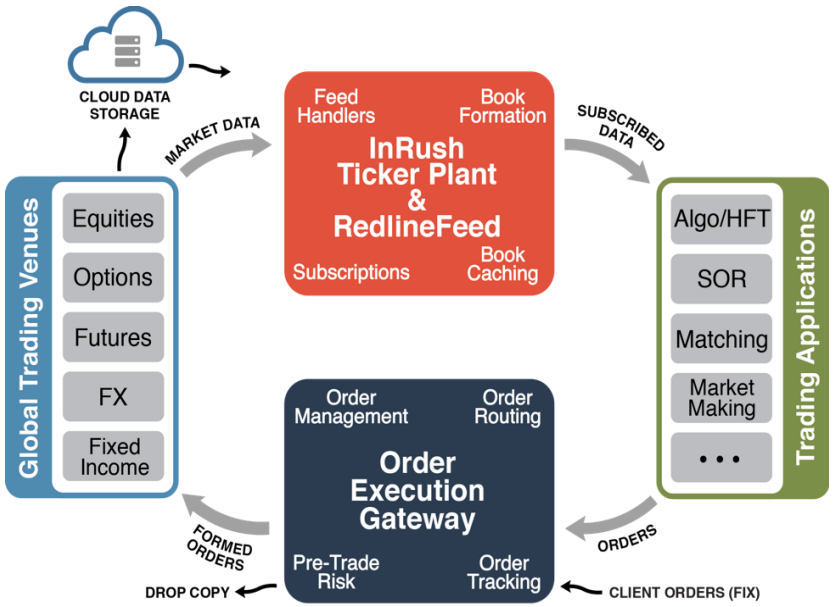
Who is Redline Trading

The leader in latency-sensitive trading solutions since 2008

- Deployed at leading banks, prop shops, hedge funds, MM, ATS's, Exchanges
- Global presence with offices in Boston, NYC, Belfast, London and Hong Kong
- Over 150 venues supported globally

Why firms choose Redline:

- Proven performance, accuracy and reliability in mission-critical applications
- Focused on maximizing trading profitability via market data insights and best execution
- Industry's smallest footprint creates dramatic reduction in operational expenses
- World-class customer care & support, 24x7



What is Market Simulation for Testing?

Testing the behavior of trading systems while interacting with Simulated Exchanges/Liquidity Providers and other Market Participants

The stakes are HIGH:

- Regulatory/Exchange Fines
- Trading Losses
- Your firm on the front page of the WSJ

…

Uses of Market Simulation for Testing

Exchange & Regulatory Compliance Testing

- Protocol Conformance and Regression Testing
- Market Impact Testing
- Stress Testing

Application Stability Testing

- Make sure you don’t lose money!!!

Application Effectiveness Testing

- Find better ways to make money!!!

Protocol conformance and regression testing

The challenge is to test your trading system under ALL of the potential "state" conditions

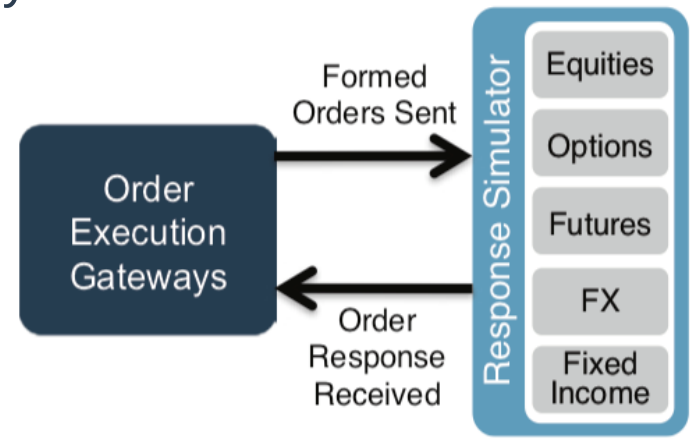
- Protocol interaction should be indistinguishable from live trading
- It is important to get consistent results each time you run

Most important test cases are targeted at anomalies and "edge" conditions

- Out-of-order responses, dropped orders, missed heartbeats, unsolicited disconnect
- Too late to cancel, busted order, halted symbol

Exchange UATs miss the mark

- Lack scriptable responses that can orchestrate specific system states
- Can't be easily integrated into on-demand testing, shared, limited hours



Regulatory Example: MiFID II Testing

Conformance Testing: Ensure correct operation of a trading strategy

- Interacts with the trading venue's matching logic as intended
- Adequately processes the data flows from the trading venues
- Does not behave in an unintended manner
- Complies with the rules and systems of the trading venues
- Does not contribute to disorderly trading conditions

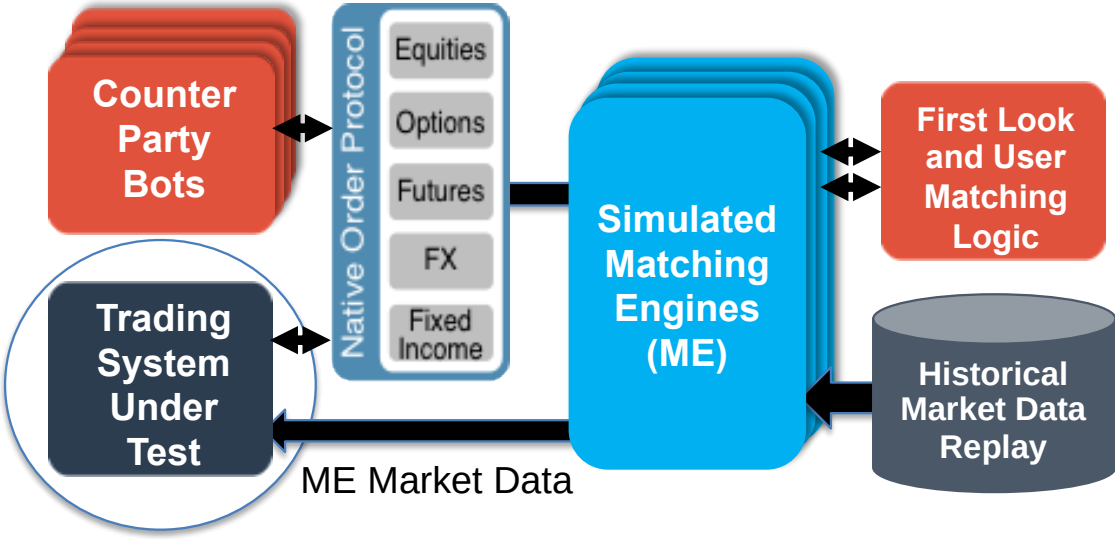
Stress Testing: Ensure that a trading system withstands increased order flows or market stresses

- Two times the maximum messages received and sent during the previous six months
- Two times the the highest volume of trading reached during the previous six months

Market Impact Testing and Stress Testing

Challenges:

- Including as much of the end-to-end production technology stack in high load testing
  - including feed handlers, order gateways, pre-trade risk, strategy logic acting together
- Creating stressing market conditions with market data state linked with order state



Trading System Effectiveness Testing

Testing a Trading Strategy to determine its effectiveness

- Effectiveness can mean different things to different strategies: profitability, risk, fill rate, VWAP performance, …
- Most common method is Backtesting (simulated trading against historical market days)
- Backtesting typically requires running against several years of data in as short a time as possible (e.g.: 1000s x real-time)

Different strategies require different simulation "fidelity"

Low Fidelity — High Fidelity

Daily Prices --- Min Bars --- Sec Bars --- Top Price Book --- Orders @ Depth

Anatomy of a High-Fidelity Exchange Simulator

Key Components

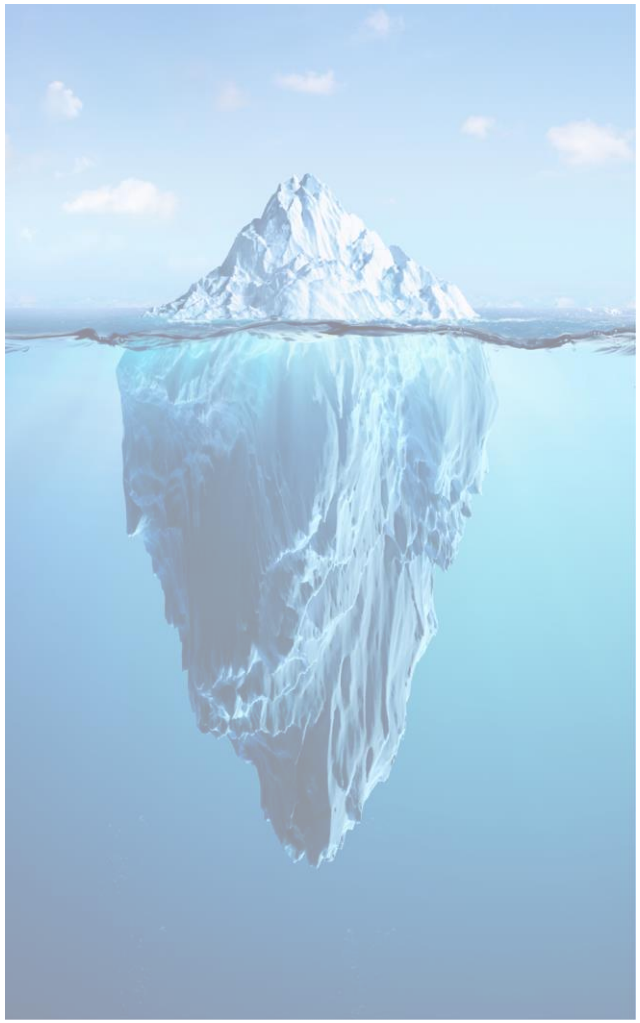
- Matching engines with venue-specific order types and matching profiles
- Historical full-depth order level market data
- Configurable latency profiles including load-based latency
- Options for counter-party bots, first look and user defined matching
- Market impact models
  - Do nothing, shift market, add orders
- Time synchronization

Example Questions for High Fidelity Simulation:

- Will lower latency improve my hit rate and strategy profitability?
- How aggressively can I trade while minimizing market impact?

Simulation testing framework –or- Production framework?

Challenge: High-Fidelity Trading on Historical Days



Modeling hidden liquidity & price discretion in the market data

- Reserve Orders
- Price Discretion/Pegged Orders

Competing against your historical self

Availability and timing of all historical inputs to the trading strategy

Latency modeling all data paths and participants

- Networking latency – Market Data and Order links
- Matching engine latency response times – Load dependent latency

Challenge: Running Faster than Real-time

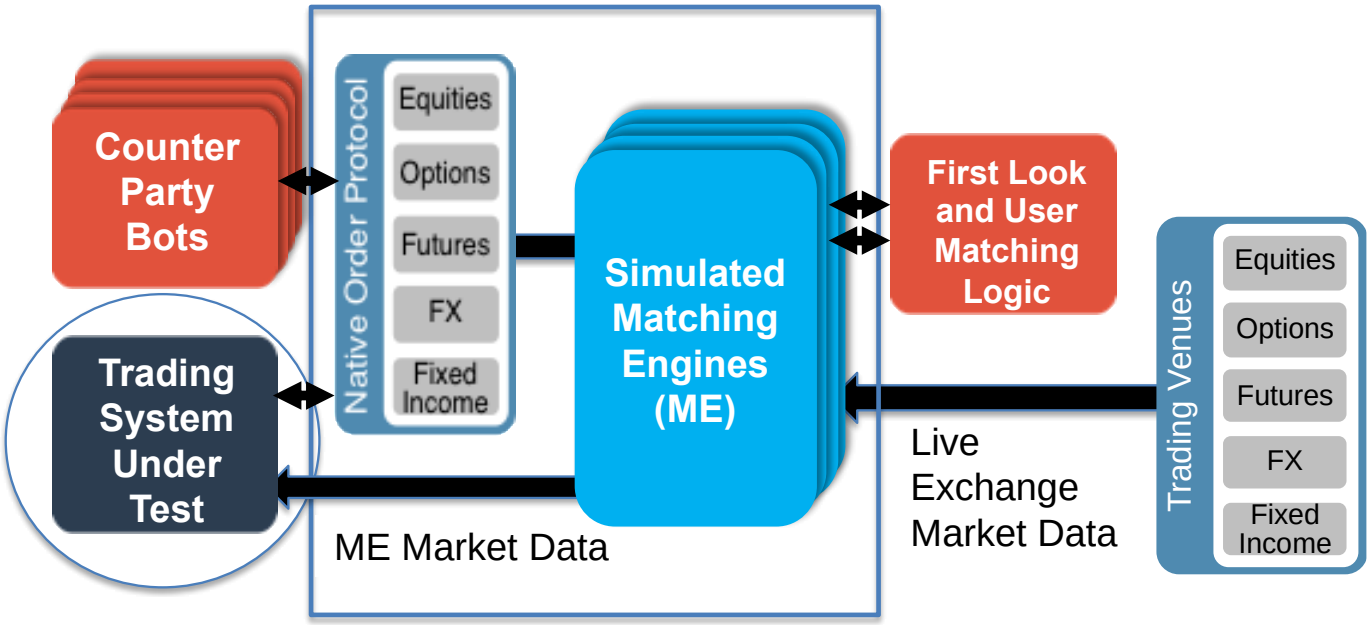
Time Synchronization!

- Simply running X-times faster does not work well in practice
- “Simulation time” needs to speed up and slow down as required by the participants
- Each participant should run full throttle until it needs to pause to ensure ordering of events with other participants
- Dependencies between components drive simulations toward serialization …

  … however latency reduces serialization! Allows for parallel processing between components

Simulating Against Live Markets

- Simulation fed by real-time market data with all of the “live” inputs that feed a production trading environment
- Can be benchmarked against an existing production trading environment running in parallel



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