

**ALLIED
TESTING**



SPECIALISTS IN QUALITY MANAGEMENT
FOR FINANCIAL APPLICATIONS



Exchange Simulator



What is Exchange Simulator?

- *An Exchange Emulator* – replicating the orderbook, trading phases, exchange rules, connectivity and data feeds
- *A data-driven Replayer* of historical orders flow against which your strategies can trade
- *A Simulator* – state of art models of market reaction in response to your own activity on orderbook

! This is not an out-of-the box product but rather a tool for internal use which can be further developed and adapted for specific needs.



Market Simulation Overview

- ✓ Market data sent to Exchange Simulator as a sequence of *submissions, cancellation and modifications*.
- ✓ *Historical trades* are ignored and replaced with the trades generated by the order matching engine based on exchange rules.
- ✓ Simulated order book deviates from the historical one after user intrusion order is submitted.
- ✓ Simulator generates a counter-flow (sequence of artificial *simulated* events) to converge a deviated book back to the historical etalon.
- ✓ Convergence happens in terms of aggregated volumes on each price level
- ✓ As a result the simulated book is built from *historical, user* and *simulated* events.



Market Impact Implementation *

- Market Impact = Temporary Impact + Permanent Impact
 - ✓ Temporary market impact – related to liquidity, by definition dissipates over time.
 - ✓ Permanent market impact – related to informational impact, by definition does not decay and thus affects subsequent executions.
- Only Temporary Market Impact is supported
 - ✓ Pros: guarantees stable and fully reproducible results for back-testing.
 - ✓ Cons: there are certain limitation for very large aggressive intrusion orders, as in this case simulation will not be fully realistic



Market Simulation: Convergence to the Historical Order Book

Simulated Volume > Historical Volume on a certain price level

- ✓ Cancellation: a non-null probability of an extra cancellation of market order is introduced.
- ✓ Trade models: a non-null probability that an extra submission of market order from the opposite side, resulting in a trade, is introduced.

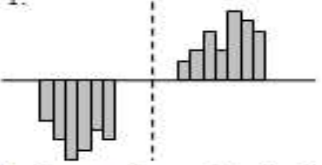
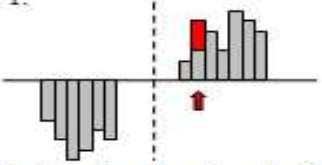
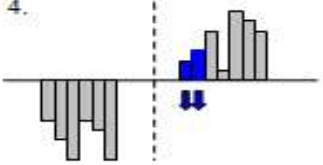
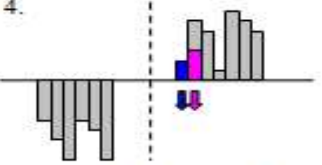
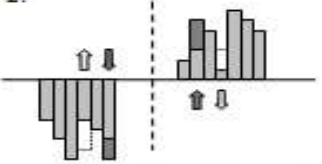
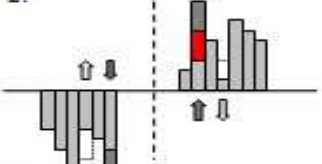
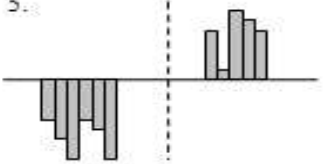
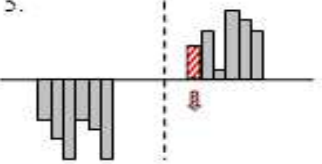
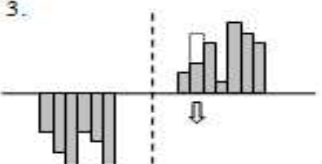
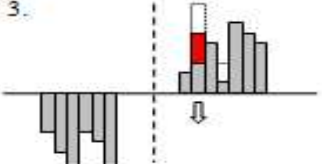
Simulated Volume < Historical Volume on a certain price level

- ✓ Submission model: passive limit orders to compensate a deficit on certain price levels are simulated in line with expected intensity.

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- ✓ Elasticity model: When mid prices of historical and simulated books are different a submission price of historical limit orders can be corrected before they submitted into the simulated book.



Example of Simulation: Dissipation of user passive limit order by the trade model

History	Simulation	History	Simulation
<p>1.</p>  <p>The historical state of the book just before the intruder order arrives.</p>	<p>1.</p>  <p>The intruder order places itself on the book, altering the historical picture.</p>	<p>4.</p>  <p>A market order or a crossing limit order comes, triggering one or more trades.</p>	<p>4.</p>  <p>When our order is first in the queue, it gets filled by the next market order. The trade will include the intruder order instead of a historical one.</p>
<p>2.</p>  <p>Order submissions and cancellations alter the state of the book.</p>	<p>2.</p>  <p>The perturbation persists; the simulator keeps track of the position of the intruder order in the respective queue. Submissions add volume <i>after</i> the intruder.</p>	<p>5.</p> 	<p>5.</p>  <p>Until there is a difference between the historical book and the simulation, extra orders left in the queue as the result of the perturbation (but not the intruder order) have a non-zero chance to get traded against a simulated market order.</p>
<p>3.</p> 	<p>3.</p> 		



Market Simulation: Supported Market Behavior Patterns

- ✓ Realistic order volumes distribution: the volumes for simulated orders are selected based on retrospectively estimated distribution of submitted order volumes.
- ✓ Behavioral regularity of simulated events: the intensity of event depends on order book side and type of event and based on retrospective empirical distribution.
- ✓ Realistic simulation of cancelation events: orders for cancellation are selected based on patience of traders, order volume and distance from mid price.
- ✓ Resiliency of order book shape: the shape of the order book is maintained in line with the historical etalon.
- ✓ Diming Model: This is model is triggered as a reaction to a large limit order near spread. A set of small or smaller limit orders on the same side of the original order for the same instrument is simulated.