How My Simulator Mimics a Real Exchange

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Introduction

Modern financial markets such as stock exchanges and cryptocurrency exchanges are organized as order driven markets. In these markets, participants submit buy and sell orders to a central exchange, which matches them according to predefined rules. Prices emerge from the interaction of supply and demand inside the order book.

We implemented a minimal but realistic market simulator that captures the core mechanics of such an exchange that focuses on the essential institutional features that govern how orders become trades.

Supported Order Types

The simulator supports two primary order types:

- **Limit orders**, which specify a price and quantity and may rest in the order book.
- **Market orders**, which do not specify a price and execute immediately against the best available prices.

Order Book

At the core of the simulator is a limit order book (LOB) with two sides:

- The bid side, containing buy orders sorted from highest to lowest price.
- The ask side, containing sell orders sorted from lowest to highest price.

Matching Mechanism and Price Formation

Orders are matched using a deterministic rule:

- A trade occurs when the best bid price is greater than or equal to the best ask price.
- Market orders execute immediately against the top of the opposite side of the book.
- Limit orders execute immediately only if they cross the book else they rest in the book.

Trades may be partial, meaning a single order can result in multiple executions at different prices. Prices in the simulator are endogenously formed, prices arise naturally from the placement and matching of orders, which is consistent with real order driven markets.

Event Driven Simulation

The simulator operates in discrete time steps, where in each step representing small interval:

1. Agents decide whether to act.
2. Orders are submitted to the market.
3. The order book processes matches.
4. Trades and snapshots are recorded.

Agents

The simulator includes multiple types of agents, each representing a simplified class of traders:

- **Random traders**, who submit limit orders with random prices and quantities.
- **Market takers**, who submit market orders to immediately buy or sell.
  Market makers, who place buy and sell limit orders around a price to provide liquidity.

Conclusion

This simulator captures the essential institutional structure of a real exchange:

- Order driven trading
- FIFO price time priority
- Endogenous price formation
- Liquidity provision and consumption
- Heterogeneous market participants

Extras

- The simulator also includes order cancellations, which are a dominant feature of real markets and play an important role in shaping liquidity and volatility.
- Agents are subject to arrival probabilities, meaning they do not act at every time step. This creates asynchronous participation, which better reflects real markets where not all traders are active simultaneously.